

Appendix G

Site 12 Supporting Documentation

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U.S. Army Center for Health Promotion and Preventive Medicine

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GEOHYDROLOGIC STUDY NO. 38-EH-8181-98
U.S. ARMY GARRISON
FORT BUCHANAN, PUERTO RICO
11-16 JUNE 1998, 4-5 MAY 1999, and
14-16 OCTOBER 1999

Volume 1 of 2

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Readiness Thru Health

U.S. Army Center for Health Promotion and Preventive Medicine

The lineage of the U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) can be traced back over 50 years. This organization began as the U.S. Army Industrial Hygiene Laboratory, established during the industrial buildup for World War II, under the direct supervision of the Army Surgeon General. Its original location was at the Johns Hopkins School of Hygiene and Public Health. Its mission was to conduct occupational health surveys and investigations within the Department of Defense's (DOD's) industrial production base. It was staffed with three personnel and had a limited annual operating budget of three thousand dollars.

Most recently, it became internationally known as the U.S. Army Environmental Hygiene Agency (AEHA). Its mission expanded to support worldwide preventive medicine programs of the Army, DOD, and other Federal agencies as directed by the Army Medical Command or the Office of The Surgeon General, through consultations, support services, investigations, on-site visits, and training.

On 1 August 1994, AEHA was redesignated the U.S. Army Center for Health Promotion and Preventive Medicine with a provisional status and a commanding general officer. On 1 October 1995, the nonprovisional status was approved with a mission of providing preventive medicine and health promotion leadership, direction, and services for America's Army.

The organization's quest has always been one of excellence and the provision of quality service. Today, its goal is to be an established world-class center of excellence for achieving and maintaining a fit, healthy, and ready force. To achieve that end, the CHPPM holds firmly to its values which are steeped in rich military heritage:

- ★ *Integrity is the foundation*
 - ★ *Excellence is the standard*
 - ★ *Customer satisfaction is the focus*
 - ★ *Its people are the most valued resource*
 - ★ *Continuous quality improvement is the pathway*

This organization stands on the threshold of even greater challenges and responsibilities. It has been reorganized and reengineered to support the Army of the future. The CHPPM now has three direct support activities located in Fort Meade, Maryland; Fort McPherson, Georgia; and Fitzsimons Army Medical Center, Aurora, Colorado; to provide responsive regional health promotion and preventive medicine support across the U.S. There are also two CHPPM overseas commands in Landstuhl, Germany and Camp Zama, Japan who contribute to the success of CHPPM's increasing global mission. As CHPPM moves into the 21st Century, new programs relating to fitness, health promotion, wellness, and disease surveillance are being added. As always, CHPPM stands firm in its commitment to Army readiness. It is an organization proud of its fine history, yet equally excited about its challenging future.



REPLY TO
ATTENTION OF

DEPARTMENT OF THE ARMY
U.S. ARMY CENTER FOR HEALTH PROMOTION AND PREVENTIVE MEDICINE
5158 BLACKHAWK ROAD
ABERDEEN PROVING GROUND, MARYLAND 21010-5403

EXECUTIVE SUMMARY
GEOHYDROLOGIC STUDY NO. 38-EH-8181-98
U.S. ARMY GARRISON
FORT BUCHANAN, PUERTO RICO
11-16 JUNE 1998, 4-5 MAY 1999, and
14-16 OCTOBER 1999

03 NOV 2000

I. PURPOSE. To investigate potential ground water, surface water, and sediment contamination from a former waste disposal area at U.S. Army Garrison, Fort Buchanan, Puerto Rico.

II. CONCLUSIONS. Only chemical parameters with at least one detection above the National Primary or Secondary Drinking Water maximum contaminant level (MCL) for ground water, the Commonwealth of Puerto Rico's maximum allowable contaminant (MAC) level for surface water, or the U.S. Environmental Protection Agency (EPA), Region III Risk Based Concentration (RBC) for soil, where applicable, are included in the conclusions. Although surface water samples are compared to the Commonwealth of Puerto Rico's MAC, surface water in intermittent streams is exempt from the MAC if certain conditions are met.

A. Ground water exists under water table conditions and flows in a northwesterly direction.

B. Low concentrations of pentachlorophenol were detected in soil, ground-water and sediment samples. Pentachlorophenol was not detected in any surface water sample. In June 1998, pentachlorophenol was detected in only one ground-water sample and the concentration was above the MCL. Pentachlorophenol was detected in three ground-water samples at concentrations below the MCL in May 1999. In October 1999, pentachlorophenol was not detected in any sample. Based on the low concentrations of pentachlorophenol in soil (below EPA, Region III, RBC for soil, residential use), ground water (below the MCL), and sediment, there is no threat to human health or the environment from this compound.

C. In samples collected in June 1998, arsenic was detected at concentrations above the MCL in the upgradient, sidegradient, and downgradient ground-water samples. Arsenic concentrations were below the MCL in field filtered samples collected in May 1999. Arsenic was not detected in three of the four unfiltered ground-water samples collected in October 1999, and was detected at a concentration less than the MCL in the fourth sample. Elevated concentrations of arsenic in the upgradient and side-gradient monitoring wells indicate that the presence of this metal in ground water is from off-site and is not due to activities associated with the waste disposal area. Elevated metal concentrations are often associated with sample

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turbidity and the first set of ground-water samples was turbid. Arsenic was not detected in soil samples (collected outside the limits of the former waste disposal area). Arsenic was detected in sediment samples collected from each of the four sampling points; the highest concentrations were reported for samples collected near one of the waste piles located within the intermittent stream channel. Arsenic concentrations were consistently above the MAC in each surface water sample collected near the waste piles within the intermittent stream channel. These samples were also more turbid than surface water samples collected downstream. Surface water samples, collected downstream from the waste piles, had arsenic concentrations above the MAC in May 1998. Samples collected in May and October 1999 at the same locations had concentrations that ranged from non-detect to less than the MAC.

D. Copper concentrations in ground water ranged from non-detect to less than the MCL. One surface water sample had a reported copper concentration equal to the MAC for surface waters. Copper was detected in each stream sediment, and soil sample and concentrations in soil were below the RBC. Based on the analytical data, copper is naturally occurring and poses no threat to human health or the environment.

E. Iron concentrations in ground water and soil exceed the secondary MCL and the RBC, respectively. High concentrations of iron were also detected in surface water and sediment samples. Based on the analytical data it is concluded that the high iron concentrations are naturally occurring and are not associated with the former waste disposal site.

F. Lead was detected in upgradient, sidegradient, and downgradient ground-water samples collected in May 1998 and October 1999. Concentrations in upgradient and sidegradient samples ranged from non-detect to below the MCL. Lead concentrations in downgradient wells were above the MCL. Lead concentrations in filtered ground-water samples ranged from non-detect to less than the MCL. Elevated (above the MCL) lead concentrations in ground water may be a function of sample turbidity. Lead concentrations in 10 of 12 surface water samples were below the MAC. The MAC was exceeded in one sample collected near a waste pile, and in one sample collected downstream of the former waste disposal area. Based on the presence of lead in upgradient and sidegradient wells, and the fluctuation of lead concentrations above and below the MCL and the MAC over time at some sampling locations, it is concluded that lead is naturally occurring or is migrating from a hydraulically upgradient area, and is not impacting surface water quality near the former waste disposal site.

G. Zinc was detected in ground-water samples at concentrations less than the secondary MCL. Zinc concentrations in surface water exceed the MAC and the MAC is lower than the secondary MCL for ground water. Zinc concentrations decrease in the downstream direction. Zinc concentrations in surface water are consistent with ground-water concentrations. Based on chemical analytical results, zinc is naturally occurring.

EXSUM, Geohydrologic Study No. 38-EH-8181-98, 11-16 Jun 98, 4-5 May 99, and 14-16 Oct 99

H. TPH was detected in the upgradient and in one downgradient ground-water sample collected in June 1998, but was not detected in any sample collected in May 1999. TPH was detected in every sediment sample but was not detected in surface water samples. The presence of TPH in stream sediments is not impacting surface water quality.

VIII. RECOMMENDATIONS. Based on the low concentrations of the analytes discussed above and in other sections of this report, no further study is recommended for the former waste disposal site.

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DEPARTMENT OF THE ARMY
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5158 BLACKHAWK ROAD
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GEOHYDROLOGIC STUDY NO. 38-EH-8181-98
U.S. ARMY GARRISON
FORT BUCHANAN, PUERTO RICO
11-16 JUNE 1998, 4-5 MAY 1999, and
14-16 OCTOBER 1999

I. INTRODUCTION.

A. References. See Appendix A for a list of references.

B. Authority. Telephone conversation between Mr. Felix Mariana, U.S. Army Garrison, Fort Buchanan, Environmental Office, and Mr. John Bauer, Program Manager, U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM), 5 and 9 March 1998.

C. Purpose. To investigate the potential impact of waste piles and former disposal practices on ground water, surface water, and sediment at a formerly used waste disposal area at the U.S. Army Garrison, Fort Buchanan, Puerto Rico.

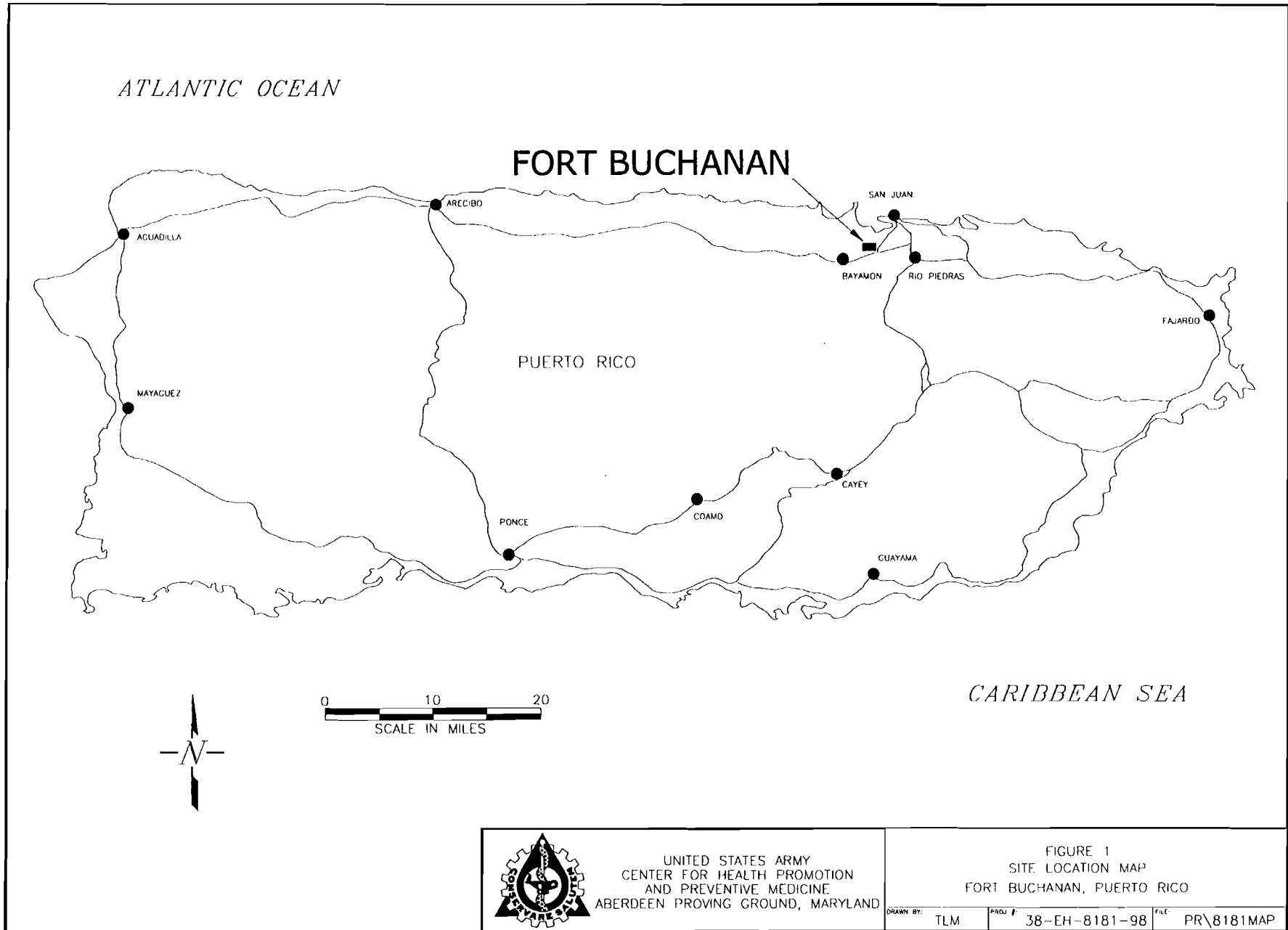
D. Project Personnel. Ms. Bridgett Lyons, Project Officer; Mr. William Smithson, Senior Engineering Technician; and Mr. Douglas Bazemore and Mr. Duane Manners, Engineering Technicians; conducted this investigation.

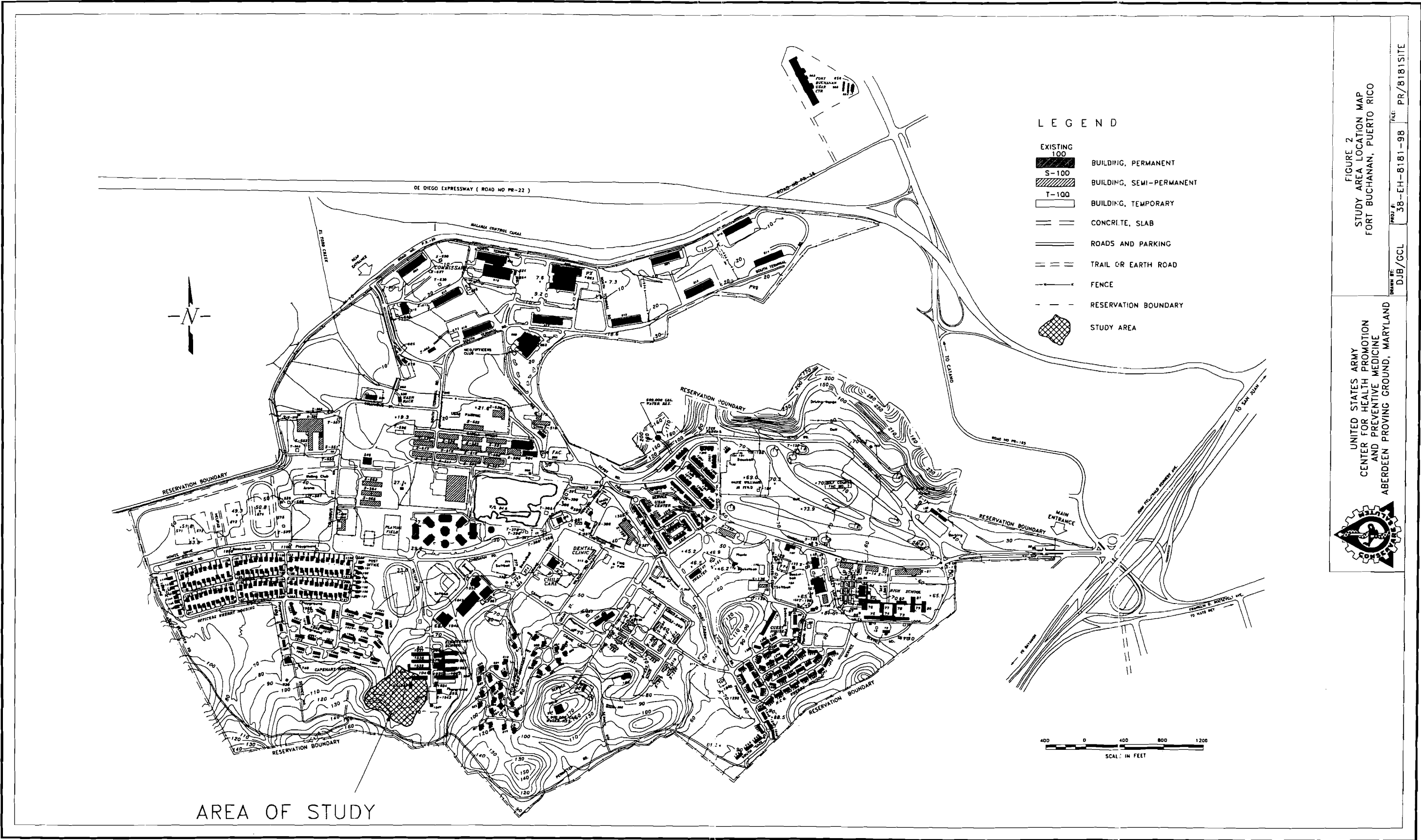
II. SITE DESCRIPTION.

A. Site Location. The U.S. Army Garrison, Fort Buchanan, is a 746-acre active installation located within the geographic region of the San Juan metropolitan area within two municipalities: Bayamon and Guaynabo (Figure 1). The former waste disposal area (the site) is located in the southwest part of the installation, adjacent to and southeast of the Buchanan Heights family housing area and southwest of the elementary school (Figure 2).

B. Past Use of the Site.

1. The 1984, Installation Assessment (reference 5) refers to the disposal area as an onsite landfill that received construction debris and tree trimmings. The disposal area is also referred to as the "Old Landfill" in the Environmental Baseline Survey Report prepared by





Woodward Clyde Federal Services, 18 January 1997 (reference 1). Although the "landfill" was not permitted, the Commonwealth of Puerto Rico's Environmental Quality Board gave informal approval of the operation (reference 5). The U.S. Navy used the disposal area from approximately 1962 until the late 1970s.

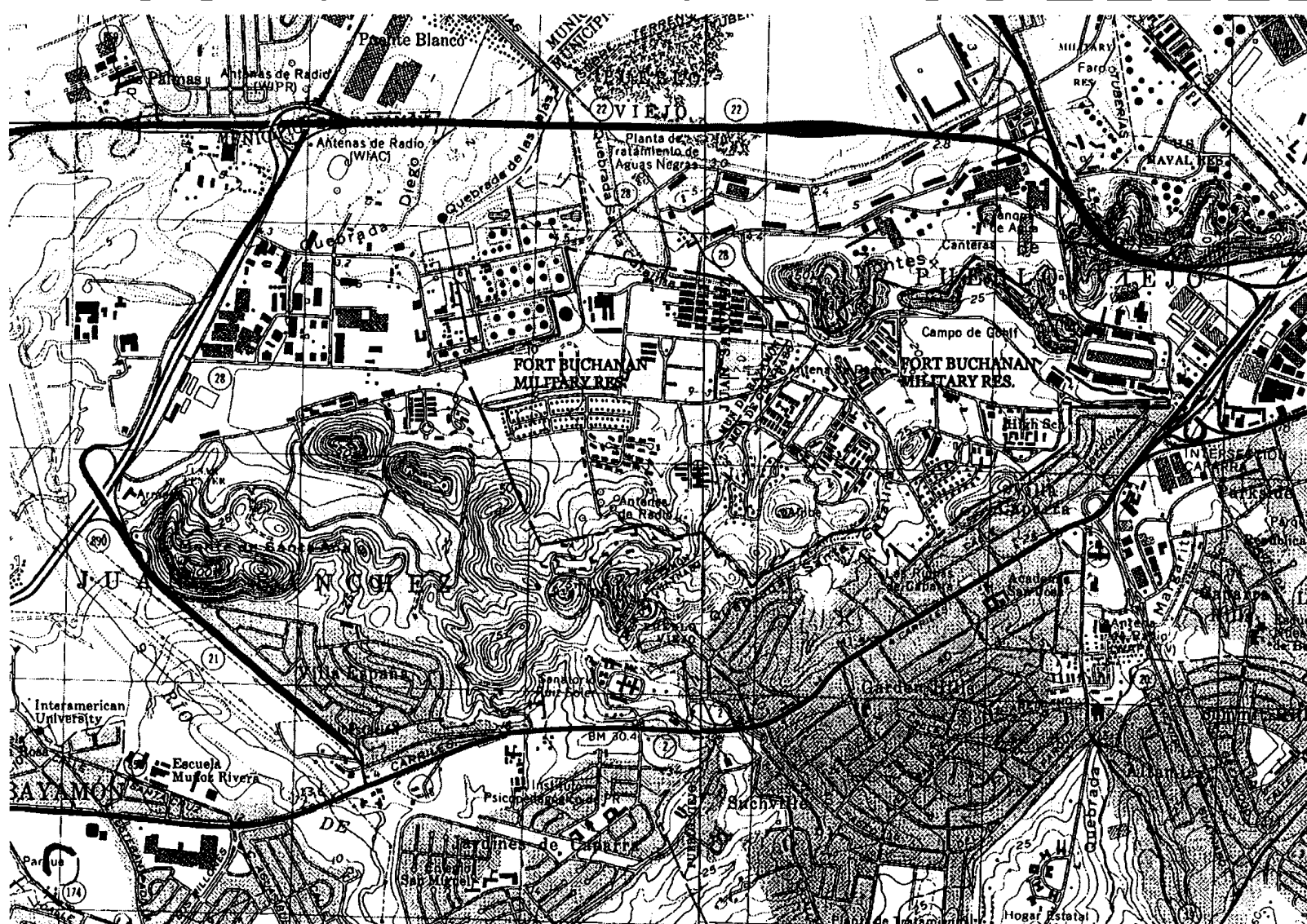
2. An interview with a former installation employee identified that uncontrolled dumping of paint cans, oil drums, and other possibly hazardous materials were periodically observed within the disposal area. Former installation personnel indicated that these materials were removed when they were observed. In August 1979, sawdust was used to clean up a diesel spill that was containerized in plastic bags and placed in the disposal area (reference 1). Fort Buchanan personnel reported that debris was placed in the disposal area and covered with soil during the Hurricane Hugo clean up in 1989 (reference 2). Personnel at Fort Buchanan also indicated that the disposal area received yard debris and grass clippings until January 1993.

III. ENVIRONMENTAL SETTING. The following information briefly describes the physical and environmental setting of the installation.

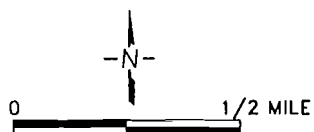
A. Climate. The climate in the San Juan area is classified as tropical. Temperatures are moderate and constant, with few hot days or chilly nights. Typically temperatures range from 74 to 86 degrees Fahrenheit (°F), with an average annual temperature of 80° F. Precipitation on Puerto Rico's main island varies geographically and seasonally. Precipitation averages about 70 to 72 inches per year island wide, with an average of 60 inches per year near the coast on the north shore. Approximately 55 percent of the average annual rainfall is lost to evapotranspiration on Puerto Rico's main island (reference 3).

B. Physiography. The Fort Buchanan installation is in the Coastal Lowlands physiographic province. In the San Juan area, a gently sloping plain, about 8 kilometers wide characterizes these lowlands, composed of alluvial materials deposited over a highly dissected older surface. Remnants of this older surface stand as isolated "haystack hills" or mogotes (limestone hills). Close to the coast lies a line of marshes, swamps, and lagoons. Further inland, the Northern Foothills rise to about 300 meters (m). These rounded hills generally consist of sandstone, siltstone, and some volcanic rocks. The installation lies within the inland side of the coastal belt of swamps and lagoons. Elevations on the installation range from 2.4 m above mean seal level (MSL), to 95 m above MSL in the mogotes area on the northeast boundary (references 4 and 5). A topographic view of Fort Buchanan and the surrounding area is shown on Figure 3.

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SOURCE: U.S. GEOLOGICAL SURVEY



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FIGURE 3
TOPOGRAPHY OF INSTALLATION AREA
FORT BUCHANAN, PUERTO RICO.

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C. Soils. Soils found on Fort Buchanan are classified as Urban land-Vega Alta complex and Almirante clay, 5-12 percent slope. The Vega Alta soils are generally well drained and located on coastal plains and stream terraces. The Almirante consists mostly of residual material, yellowish-brown clay, from the decomposition of limestone. The Almirante soils are located on coastal plains and valleys between limestone hills and are well drained with moderate permeability and medium runoff (references 1 and 6).

D. Vegetation.

1. Fort Buchanan was deforested by the 1930's. A mature mixed secondary forest colonized some of the peripheral areas of the installation. The steep hillsides located near the east-central border support typical limestone hill vegetation, including two endangered species (*Coccoloba rugosa* and *Ottoschultzia rhodoxylon*). Younger secondary forests are found in the lower hills along the southern and western boundaries of the installation. The vegetation is a mix of fast-growing native trees and exotics, including mango, cassia, and acacias. The majority of the remainder of land on the installation is maintained in grassy lawns with planted, exotic shade trees around buildings and lining avenues (reference 5).

2. No forested wetlands or mangrove areas are found on the installation. Most of Fort Buchanan occupies a well drained inner coastal valley. Small wetland areas may be included along Quebrada Toro in a northwestern section of the installation (reference 5).

E. Surface Water.

1. Three creeks cross the Fort Buchanan installation. The largest of these, El Toro Creek, carries most of the storm water from land adjacent to and from the installation itself. El Toro Creek originates south of the installation in a residential area, flows in a northerly direction across the installation, and joins the Malaria Control Canal on the north side of Fort Buchanan. El Toro Creek is a concrete-lined ditch over most of its length and discharges into the Bay of San Juan (reference 5). A spring-fed pond, owned by the Puerto Rico Cement Company, is located in the center of Fort Buchanan (references 1 and 6).

2. The surface waters at Fort Buchanan are classified by the Commonwealth of Puerto Rico as Class SD waters and are subject to water quality criteria (reference 5). Exceptions to water quality standards apply to surface, coastal, estuarine and ground waters where it is demonstrated that the natural background concentration exceeds the established water quality standards. Intermittent streams are also exempt from the Commonwealth's water quality standards when conditions of Section 4.3 of the Puerto Rico Environment Codified Regulations are met (reference 8).

F. Geology.

1. The North Coast Limestone underlies about 700 square miles of the northern one-third of Puerto Rico and extends eastward from Rincón in western Puerto Rico to Loíza, a distance of approximately 85 miles. This unit extends from the Atlantic Ocean southward to a central east-west ridge that is part of the Cordillera Central Mountain Region. The North Coast Limestone is a thick sequence of platform carbonates and minor clastics ranging in age from middle Oligocene to Miocene. The surface exposure sequence of the North Coast is characterized by tropical karst topography. The karst topography in the eastern part of Puerto Rico, which includes the municipality of San Juan, is in an older stage of development and is characterized by low topographic relief with little or no active dissolution of limestone, and by surface, rather than underground drainage (reference 7).

2. The outcrop area of the North Coast Limestone is approximately 2 miles wide in San Juan. The major units of the North Coast Limestone in ascending order are: the San Sebastian Formation, the Lares Limestone, the Mucarabones Sand, the Cibao Formation, the Aguada Limestone, the Aymamón Limestone, and the Camuy Limestone (reference 7). These units range in age from middle Oligocene to Miocene. These rock units dip gently northward at an average dip of 3 to 4 degrees; dips range from 2 degrees near the coast to 6 or 7 degrees where these rocks lie in contact with the volcanic core of Puerto Rico. The Aguada and Aymamón Limestones are resistant rocks and tend to form ridges and cap the mogotes. The hills located on Fort Buchanan are rich in limestone, and outcrops of limestone are found in the hills (reference 1). Quaternary alluvium mantels most of Fort Buchanan, although the Cibao Formation and the Mucarabones outcrop in the southern part of the installation. The uppermost part of the Cibao Formation consists of claystone, marl, and limestone containing terrigenous material (reference 7). The mogote, which forms the reentrant in the installation boundary, consists of the Aguada Limestone (reference 3).

G. Hydrogeology. The Aguada and Aymamón Limestones, along with the upper portions of the Cibao Formation, form a prolific water-table aquifer, which extends in a narrow band along the northern coast of Puerto Rico. The aquifer's extent is limited by the saltwater interface on the coastal side and by the landward thinning and eventual absence of the limestones. At Fort Buchanan, the limestones have been mostly removed by erosion, existing only as isolated mogotes. The San Sebastian and lower portion of the Cibao Formations constitute another aquifer, which is under confined conditions in much of the San Juan area. Regionally ground-water flow is from the southwest to the northeast; however, local variations in the direction of ground-water flow exist due to irregular topography (reference 6). The ground-water flow rate in the uppermost aquifer, at an adjacent property located to the northwest of Fort Buchanan, is estimated to range from 3.3 to 7.8 feet per year (reference 1).

H. Disposal Area Setting. The former waste disposal area is located south of the installation's elementary school, southeast of the Buchanan Heights housing area, south of the soccer field, and adjacent to a portion of the installation boundary. The USACHPPM did not delineate the boundary of the former waste disposal area as shown on Figure 4. The boundary of the former waste disposal area is consistent with the former waste disposal area boundaries delineated in previous reports. As shown on Figure 4, the waste disposal area extends into the elementary school's property. The area monitoring wells MW-02 and MW-04 are installed in a maintained grassy lawn that extends to and surrounds the elementary school's buildings. The southern portion of the former waste disposal area is a relatively flat area with rock exposure on the surface and little vegetation. A chain link fence with a locked gate surrounds this section of the site. The western part of the site is heavily vegetated and the ground surface slopes steeply toward an unnamed intermittent stream. A cement pipe, which discharges water from an unknown source, is present on the eastern side of the intermittent stream immediately south of the soccer field. The intermittent stream is diverted under the ground surface by engineered controls on the south side of the soccer field. The intermittent stream flows into a tributary of El Toro Creek near the northwest boundary of Fort Buchanan.

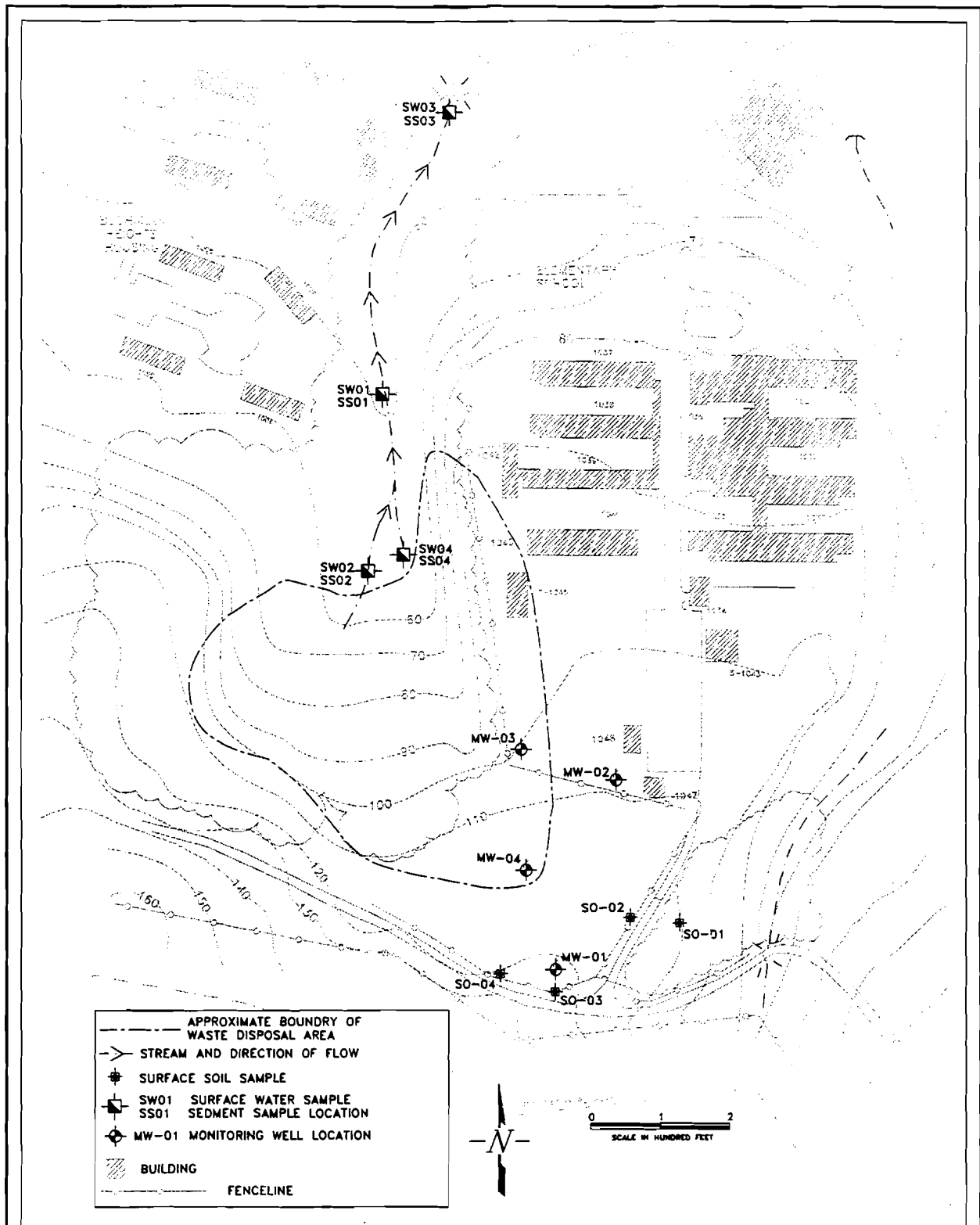
IV. FIELD INVESTIGATION.

A. Field Program. The field investigation consisted of:

- (1) Drilling four soil borings;
- (2) Installing four monitoring wells;
- (3) Surveying the horizontal and vertical positions of the monitoring wells;
- (4) Collecting ground-water levels at each monitoring well;
- (5) Collecting one set of soil samples along the perimeter fence line; and
- (6) Collecting three sets of ground-water, surface water, and sediment samples.

USACHPPM personnel conducted drilling and well installations 11-16 June 1998. Monitoring well locations and surface water and sediment sampling locations are provided on Figure 4. Drilling, monitoring well construction, well development, and sampling techniques are provided in Appendix B. Ground water, surface water and sediment were sampled 15-16 June 1998. Confirmatory ground-water, surface water and sediment samples were collected 4-5 May 1999. Shallow soil samples were also collected in May 1999. Due to conflicting data, a third set of ground-water, surface water and sediment samples, analyzed for a reduced number of parameters, was collected on 14 and 16 October 1999. Sample parameters are discussed in paragraph V.C. and are summarized in Table 1.

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FIGURE 4
MONITORING WELLS AND SAMPLE LOCATIONS
FORT BUCHANAN, PUERTO RICO.

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TABLE 1. SAMPLE COLLECTION DATES, MATRICES, AND ANALYSES.

MATRIX	Analyses					
	VOCs ¹	SVOCs ²	Metals		Pesticides, Herbicides, and PCBs ³	TPH ⁴
			Total	Dissolved		
Ground water	June 1998 May 1999	June 1998 May 1999 Oct. 1999	June 1998 Oct. 1999	May 1999	June 1998 May 1999 Oct. 1999	June 1998 May 1999
Surface water		June 1998 May 1999 Oct. 1999	June 1998 May 1999 Oct. 1999		June 1998 Oct. 1999	June 1998 May 1999
Sediment		June 1998 May 1999	June 1998 May 1999 Oct. 1999		June 1998 May 1999 Oct. 1999	June 1998 May 1999
Soil			May 1999		May 1999	

Notes: ¹VOCs- Volatile Organic Compounds

²SVOCs - Semivolatile Organic Compounds

³PCBs - Polychlorinated biphenols

⁴TPH - Total Petroleum Hydrocarbons

B. Soil Borings and Monitoring Wells. Four borings, B-1 through B-4, inclusive, were drilled to obtain stratigraphic information and to provide for monitoring well installation. Monitoring wells MW-01 through MW-04, inclusive, were installed in borings B-1 through B-4, respectively. A general diagram of monitoring well construction is shown in Appendix B. Borings B-3 (MW-03) and B-4 (MW-04) are located within the waste disposal area and borings B-1 (MW-01) and B-2 (MW-02) are located to the southeast of the disposal area (see Figure 4). Boring B-2 is also located immediately downgradient of Building 1047. Building 1047 is a paint storage locker, and several old air conditioning units were observed on the ground behind the building. Steep slopes along a ravine, dense vegetation, and land use restricted the placement of monitoring wells. Borings were advanced until approximately 15 - 20 feet of ground water had been encountered. Boring logs are contained in Appendix C.

C. Surface and Sediment Samples. Four surface water (SW) and sediment sample (SS) points were established along the intermittent stream west of the disposal area. The sample points were marked and surveyed. The southern most sample points were selected based on the presence of debris piles and the origination of water from beneath the piles. One sample point (SW01, SS01) was established at the approximate midpoint of the stream's reach. The fourth sample point (SW03, SS03) was established at the northern most point of the stream before being diverted under the ground surface.

D. Surface Soil Samples. Four surface soil sample points labeled SO-01 through SO-04 were established during the field program (Figure 4). Three sample points, SO-02 through SO-04 were collected along a fence line topographically upgradient from the waste disposal area. Herbicides are reported to be used along the fence line. The fourth soil sample point, SO-01, was collected in a wooded area and is used as a background sample. Sample collection procedures are described in Appendix B.

V. FINDINGS AND DISCUSSION.

A. Waste Piles.

1. In June 1998, two waste piles approximately 40 feet in diameter were observed along the eastern slope of the densely vegetated ravine. One waste pile was located immediately north of sample point SW02, SS02 (Figure 4) and the other was located immediately north of sampling point SW04, SS04. The surface of the piles appeared to be decomposing grass and other vegetation. Chain-link fencing, fence posts, cement, and construction rubble were observed in the waste area near MW-04. North of this area old mattresses, a washing machine, a rusted 55-gallon drum, and old motor oil containers were seen. An asphalt or tar-like substance was observed in the rusted 55-gallon drum.

2. In September 1998, Hurricane Georges struck Puerto Rico. The effects of the hurricane included denuded hillsides, felled power lines, downed trees, and floods. During the May 1999 site visit, a change in the appearance of the waste piles and the ravine area was observed. The waste pile locations were not as distinctive as previously observed, showing evidence of erosion and washing. Many trees in the area were also down and scattered about the ravine area.

B. Site Geology and Hydrogeology.

1. Weathered rock outcrops at the surface immediately southeast of the former disposal area boundary. The line delineating the southeastern boundary of the disposal area and the fence lines along the southern boundary of the installation and the road approximate the outcrop area (Figure 4). The subsurface material consists primarily of interbedded weathered to highly weathered rock and silty clay.

2. Ground water exists under water table conditions. Three sets of ground-water measurements were collected and are presented in Table 2. Ground-water elevations fluctuated slightly. Depth to ground water ranged from 8.8 to 28.5 feet below ground surface (bgs) across the site. Generally, the depth to ground water is less in the topographically high areas and depths increase toward the north.

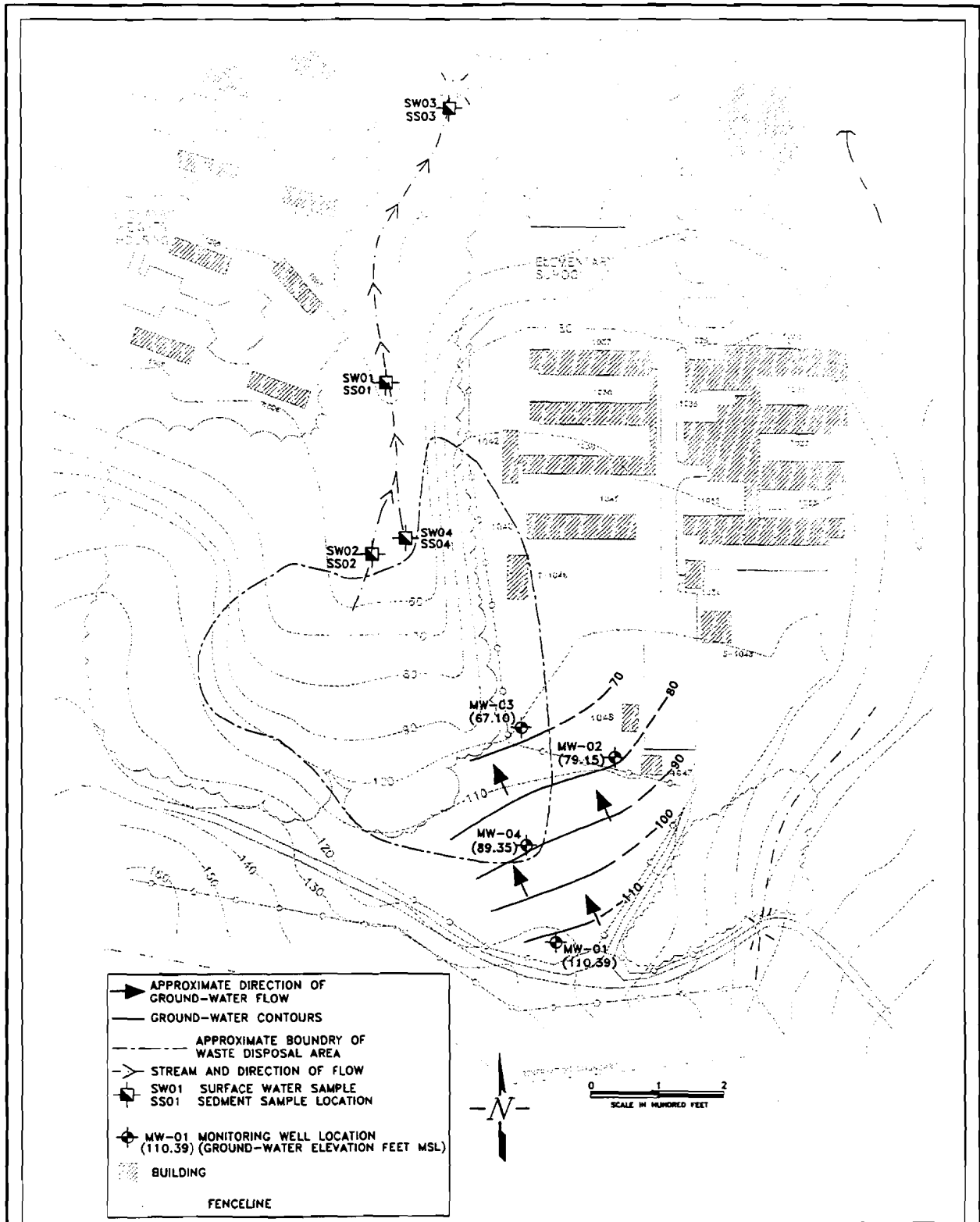
TABLE 2. GROUND-WATER MEASUREMENTS AND ELEVATIONS

Monitoring Well	Top of Casing Elevation (feet MSL)	Depth to Ground water (below TOC)			Ground-water Elevation (feet MSL)		
		June 1998	May 1999	Oct. 1999	June 1998	May 1999	Oct. 1999
MW-01	120.74	8.85	10.35	9.73	111.89	110.39	111.01
MW-02	107.02	26.74	27.87	27.81	80.58	79.15	79.21
MW-03	96.77	28.49	29.67	29.05	68.28	67.10	67.72
MW-04	114.40	20.66	25.05	24.40	93.74	89.35	90.00

Notes: MSL - mean sea level
TOC - top of casing.

3. A ground-water elevation contour map (Figure 5) was prepared based on water levels measured in wells MW-01 through MW-04 on 3 May 1999. As shown on Figure 5, the general direction of ground-water flow is generally to the northwest toward the unnamed intermittent stream. The configuration of ground-water elevation contours is consistent for all three sets of ground-water elevation data. Monitoring well MW-01 is hydraulically upgradient from the waste disposal area. Monitoring well MW-02 is a sidegradient located outside the historically delineated limits of the waste disposal area. Due to the location of MW-02, chemical data from this well and MW-01 can be used to establish chemical background concentrations.

4. Water was present in the intermittent stream area during the field investigation. The water appeared to originate from beneath the waste piles along the eastern slope of the ravine. Because of this, no up-stream (background) surface water sample could be collected. During low flow the water originating from the waste piles had a sheen and what appeared to be a bacterial growth that was a reddish color. The bacterial growth and sheen were not observed during high flow conditions in May 1999. Concrete piping, possibly remnants of an artificial channel, was also observed along portions of the streambed. Surface water was ponded in the ravine extending approximately from the waste piles to north of surface water sampling location SW01. A concrete pipe discharges water to the stream immediately south of the soccer field near surface water sample location SW03.



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ABERDEEN PROVING GROUND, MARYLAND

FIGURE 5
GROUND-WATER CONTOURS, 3 MAY 1999,
FORT BUCHANAN, PUERTO RICO

DRAWN BY: DJB/GCL	PROJ #: 38-EH-2632-99	FILE: PR/8181SAMP
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C. Sample Analyses and Results.

1. Sample Analyses.

a. June 1998 Sample Analyses.

(1) The ground-water, surface water, and sediment samples collected in June 1998 were analyzed for SVOCs, total metals, herbicides, pesticides, PCBs, and TPH. Due to laboratory oversight, the analyses for metals in sediments did not include iron. Additionally, ground-water and surface water samples were analyzed for volatile organic compounds (VOCs). Gascoyne Laboratories, Inc. analyzed sediment samples for metals. All other samples were analyzed by the USACHPPM's analytical laboratory at Aberdeen Proving Ground (Edgewood Area). Methods used to analyze samples are summarized and are included on laboratory data sheets in Appendix D

(2) A duplicate ground-water sample (MW-05) was collected from monitoring well MW-03. A duplicate sediment sample (SS05) was collected from sediment sample location SS03. Duplicate sample results were consistent with the results of normal samples. Sample matrices and analyses are summarized in Table 1. Results are summarized on Tables 3-6. Surface water samples were collected during low flow conditions and were very turbid. Due to a combination of factors, including the close proximity of well installation to well development and purging (time wise), and purging techniques, ground-water samples were turbid. Surface soil samples were not collected during this sampling event.

b. May 1999 Sample Analyses.

(1) To confirm the results of the first sample set, a second set of ground-water, surface water, and sediment samples were collected in May 1999. Additionally, shallow soil samples were collected and analyzed for metals, pesticides, herbicides, and PCBs. Soil sample locations are provided on Figure 4. As shown on Table 1, sample media were analyzed for the same parameters as the first sampling event, with the exclusion of pesticides, PCBs, and herbicides analyses of surface water samples. These parameters were excluded from surface water analyses because none were detected in the first surface water sampling set. Lancaster Laboratories, Incorporated (Lancaster), Lancaster, Pennsylvania, performed herbicides analyses of ground-water, soil, and sediment samples. The USACHPPM's analytical laboratory analyzed all other samples.

(2) Ground-water samples collected for the metal analyses were filtered in the field. A duplicate ground-water sample (MW-05) was collected from monitoring well MW-03. Samples collected for VOCs analyses exceeded a pH of 2, indicating that preservation

TABLE 3. SUMMARY OF CHEMICAL ANALYTICAL RESULTS FOR GROUND-WATER SAMPLES

Sample ID	Drinking Water Standard	MW01			MW02			MW03			MW04			MW05**		
Sample Date		6/16/98	5/4/99	10/16/99	6/16/98	5/4/99	10/16/99	6/16/98	5/4/99	10/16/99	6/16/98	5/4/99	10/16/99	6/16/98	5/4/99	10/16/99
Volatile Organic Compounds (µg/l)																
Chloroform	100	8.6	8.9	NA	<2.0	<2.0	NA	<2.0	<2.0	NA	6.3	5.2	NA	<2.0	<2.0	NA
4-Isopropyltoluene	NS	<2.0	<2.0	NA	<2.0	<2.0	NA	1.7J	<2.0	NA	<2.0	<2.0	NA	1.5J	<2.0	NA
Semivolatile Organic Compounds (µg/l)																
Bis (2-Ethylhexyl)-Phthalate	NS	5J	5.1J	NA	<10	34	NA	<10	<10	NA	27	15	NA	<10	<10	NA
Hexachlorobutadiene	NS	<10	<10	NA	<10	<10	NA	6J	<10	NA	<10	<10	NA	<10	<10	NA
Pentachlorophenol	1	<20	<20	NA	<20	<20	NA	20J	<20	NA	<20	<20	NA	22	<20	NA
Metals (Total 6/16/98 & 16/10/99) (Dissolved 5/4/99) (µg/l)																
Arsenic	50	85	3.2	<4.0	62	4.8	<4.0	100	12	10	140	2.7	<4.0	130	12	24
Barium	2000	132	70	71	122	110	110	326	240	240	278	110	130	424	240	390
Cadmium	5	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	2.8	<2.0	<2.0	<2.0	<2.0	<2.0	5.4	<2.0	<2.0
Chromium	100	<20	<20	<4.0	<20	<20	<4.0	<20	<20	<4.0	66	<20	<4.0	47	<20	24
Cobalt	NS	<4.0	<50	<4.0	<4.0	<100	<4.0	4.8	<100	<4.0	38	<100	<4.0	20	<100	14
Copper	1300	5.8	<10	<5.0	7.5	<10	5.8	13	<10	7.2	110	<10	6.1	45	<10	30
Iron	300*	1,800	98	350	8,600	110	170	19,000	4,200	5,800	75,000	240	350	52,000	5,200	35,000
Lead	15	12	2.5	<11	12	<2.0	<11	30	2.1	25	28	<2.0	21	31	2.6	20
Nickel	100	23	<50	<10	<10	<50	<10	<10	<50	<10	32	<50	<10	28	<50	11
Selenium	50	<4.0	<5.0	<5.0	<4.0	<5.0	<5.0	<4.0	<5.0	<5.0	<4.0	<5.0	<5.0	5.1	<5.0	<5.0
Zinc	5000*	75	<20	55	94	29	72	74	<20	100	237	<20	83	189	<20	140
Total Petroleum Hydrocarbons (µg/l)																
EPA Method 418.1	NS	220	<200	NA	<200	<200	NA	<200	<200	NA	210	<200	NA	<200	<200	NA
Pesticides, PCBs, & Herbicides (µg/l)																
Pentachlorophenol	1	<0.50	<0.05	<0.05	<0.50	0.07	<0.05	11.2	0.024J	<0.05	<0.50	0.09	<0.05	8.88	0.015J	<0.05
2,4,5-TP (Silvex)	50	<0.50	<0.05	<0.05	<0.50	<0.052	<0.05	<0.50	<0.049	<0.05	<0.50	0.432	<0.05	<0.50	<0.048	<0.05
2,4,5-T	NS	<0.50	0.017J	<0.05	<0.50	<0.052	<0.05	<0.50	<0.049	<0.05	<0.50	<0.051	<0.05	<0.50	<0.048	<0.05
Dinoseb	7.0	<0.50	<0.26	<0.05	<0.50	<0.26	<0.05	<0.50	0.076J	<0.05	<0.50	0.152J	<0.05	<0.50	<0.24	<0.05
Dicamba	NS	<0.50	0.101	<0.05	<0.50	0.086	<0.05	<0.50	0.096	<0.05	<0.50	0.089	<0.05	<0.50	0.090	<0.05
2,4-DB	NS	<0.50	0.11J	<0.05	<0.50	<0.052	<0.05	<0.50	0.189J	<0.05	<0.50	0.65	<0.05	<0.50	<0.48	<0.05

Notes: Analytes included in this table were present in concentrations above the detection limit in at least one sample.

< Indicates compound was analyzed for but not detected at the numerical method detection limit stated.

Concentrations in bold print and shaded are above the current maximum contaminant level (MCL) for the National Primary and Secondary Drinking Water Regulations.

Unless otherwise noted, the Drinking Water Standards are the National Primary Drinking Water Regulation MCL.

* National Secondary Drinking Water Regulation. **Duplicate Sample.

J Indicates the reported value is an estimate.

NA Not Analyzed. NS No Standard

TABLE 4. SUMMARY OF CHEMICAL ANALYTICAL RESULTS FOR SURFACE WATER SAMPLES.

Sample ID	Puerto Rico Standards*	SW01			SW02			SW03			SW04			SW05**	
Sample Date		6/15/98	5/5/99	10/16/99	6/15/98	5/5/99	10/16/99	6/15/98	5/5/99	10/16/99	6/15/98	5/5/99	10/16/99	5/5/99	10/16/99
Volatile Organic Compounds (µg/l)															
Semivolatile Organic Compounds (µg/l)															
Bis (2-Ethylhexyl)phthalate	NS	< 10	< 10	NA	< 10	16	NA	< 10	< 10	NA	< 10	9.8J	NA	< 10	NA
Di-n-butylphthalate	NS	< 10	< 10	NA	< 10	< 10	NA	< 10	< 10	NA	< 10	14B	NA	< 10	NA
Metals (µg/l)															
Arsenic	50	130	4.8	< 4.0	410	280	590	85	3.6	< 4.0	430	100	290	4.2	310
Barium	1,000	250	77	96	889	470	1,200	90	74	83	1,120	410	740	77	730
Chromium	NS	< 20	< 20	< 4.0	< 20	< 20	19	< 20	< 20	< 4.0	28	< 20	16	< 20	14
Cobalt	NS	6.7	< 100	< 4.0	8.9	< 100	11	< 4.0	< 100	< 4.0	23	< 100	14	< 100	29
Copper	40	10	< 10	6.8	6.4	12	31	< 5.0	< 10	5.9	40	< 10	23	< 10	23
Iron	NS	24,000	520	1,000	289,000	90,000	480,000	1,200	190	670	282,000	29,000	240,000	< 200	140
Lead	50	34	< 2	12	17	7.2	11	13	< 2.0	111	58	2.9	14	< 2.0	42
Nickel	NS	11	< 50	< 10	< 10	< 50	14	< 10	< 50	< 10	24	< 50	15	< 50	< 10
Zinc	50	82	< 20	91	130	80	150	36	< 20	97	279	26	110	< 20	240
Total Petroleum Hydrocarbons (µg/l)															
Pesticides, PCBs, & Herbicides (µg/l)															

Notes: No VOCs, TPHs, pesticides, PCBs, or herbicides were detected in any surface water sample.

Analytes included in this table were present in concentrations above the detection limit in at least one sample.

* Maximum allowable concentration of certain substances in surface waters of the Commonwealth of Puerto Rico (reference 8).

Concentrations in bold print and shaded are equal to or above Puerto Rico Water Quality Standards

May 5 1999 sampling event: SW05 is a duplicate of SW03. October 1999 sampling event SW05 is a duplicate of SW04.

< Indicates compound was analyzed for but not detected at the numerical method detection limit stated.

J Indicates the reported value is an estimate.

B Indicates analyte was found in the associated blank as well as in the sample.

NA Not Analyzed.

NS No Standard

TABLE 5. SUMMARY OF CHEMICAL ANALYTICAL RESULTS FOR SEDIMENT SAMPLES

Sample ID	SS01 (Sed 01)			SS02 (Sed 02)			SS03 (Sed 03)			SS04 (Sed 04)			SS05 (Sed 05)***		
Sample Date	6/15/98	5/5/99	10/16/99	6/15/98	5/5/99	10/16/99	6/15/98	5/5/99	10/16/99	6/15/98	5/5/99	10/16/99	6/15/98	5/5/99	10/16/99
Semivolatile Organic Compounds (µg/kg)															
Fluoranthene	790	<510	NA	<630	<1,000	NA	<430	<410	NA	<550	<500	NA	<450	<370	NA
Benzo[a]anthracene	530J	<510	NA	<630	<1,000	NA	<430	<410	NA	<550	<500	NA	<450	<370	NA
Chrysene	490J	<510	NA	<630	<1,000	NA	<430	<410	NA	<550	<500	NA	<450	<370	NA
Benzo[b]fluoranthene	430J	<510	NA	<630	<1,000	NA	<430	<410	NA	<550	<500	NA	<450	<370	NA
Benzo[k]fluoranthene	470J	<510	NA	<630	<1,000	NA	<430	<410	NA	<550	<500	NA	<450	<370	NA
Benzo [g,h,i]prylene	370J	<510	NA	<630	<1,000	NA	<430	<410	NA	<550	<500	NA	<450	<370	NA
Benzo [a]pyrene	540J	<510	NA	<630	<1,000	NA	<430	<410	NA	<550	<500	NA	<450	<370	NA
Indeno [1,2,3,cd]pyrene	400J	<510	NA	<630	<1,000	NA	<430	<410	NA	<550	<500	NA	<450	<370	NA
Pyrene	770	<510	NA	<630	<1,000	NA	<430	<410	NA	<550	<500	NA	<450	<370	NA
Di-n-butylphthalate	<570	330JB	NA	<630	940JB	NA	<430	310JB	NA	<550	390JB	NA	<450	330JB	NA
Metals (µg/kg)															
Arsenic	27,000	<69,000	44,000	21,000	200,000	120,000	2,900	<56,000	6,700	5,100	<66,000	22,000	3,000	<53,000	29,000
Barium	160,000	96,000	270,000	95,000	260,000	220,000	34,000	31,000	68,000	54,000	48,000	86,000	34,000	110,000	49,000
Cadmium	3,000	<3,500	<2,000	4,000	<6,900	6,500	<2,000	<2,800	<1,900	3,000	<3,300	<2,000	<2,000	<2,700	<2,000
Chromium	15,000	35,000	28,000	22,000	<17,000	20,000	14,000	20,000	12,000	32,000	31,000	28,000	18,000	20,000	22,000
Cobalt	16,000	<17,000	17,000	<10,000	<35,000	10,000	<10,000	<14,000	<9,700	<10,000	<16,000	17,000	<10,000	<13,000	10,000
Copper	15,000	31,000	30,000	28,000	14,000	17,000	23,000	20,000	19,000	29,000	29,000	25,000	16,000	20,000	30,000
Iron	NA	23,000,000	30,000,000	NA	79,000,000	69,000,000	NA	13,000,000	15,000,000	NA	16,000,000	19,000,000	NA	14,000,000	13,000,000
Lead	15,000	<35,000	24,000	21,000	<69,000	<20,000	19,000	<28,000	<19,000	22,000	33,000	26,000	7,000	<27,000	<20,000
Mercury	<190	<170	70	<200	<360	100	<130	<130	<33	<150	<160	110	<130	<130	110
Zinc	50,000	84,000	94,000	83,000	100,000	120,000	29,000	42,000	65,000	72,000	100,000	130,000	29,000	32,000	110,000
Total Petroleum Hydrocarbons (µg/kg)															
EPA Method 418.1	78,000	54,000	NA	84,000	100,000	NA	94,000	170,000	NA	81,000	190,000	NA	126,000	54,000	NA
Pesticides, PCBs, & Herbicides (µg/kg)															
Chlordane, cis	68	<10	17,000	<8	20	<10	<8	<10	17	<8	<10	<10	<8	<10	<10
Chlordane, trans-	75	<10	13,000	<8	22	<10	<8	<10	24	<8	<10	<10	<8	<10	<10
Chlordene, gamma-	20	NA	NA	<8	NA	NA	<8	NA	NA	<8	NA	NA	<8	NA	NA
DDD,p,p'	<20	<10	<50	<20	<10	<50	<20	<10	<50	<20	22	<50	<20	<10	<50
DDE,p,p'	<16	<10	<50	<16	<10	<50	<16	<10	<50	<16	32	<50	<16	<10	<50
DDT,p,p'	<30	<10	<250	<30	<10	<250	<30	<10	<250	<30	19	<250	<30	<10	<250
Dicamba	<50	<3.0	<50	<50	<5.2	<50	<50	2.3	<50	<50	3.2	<50	<50	<2.1	<50
Dinoseb	NA	25	NA	NA	<26	NA	NA	8.0J	NA	NA	<15	NA	NA	10.2J	NA
Heptachlor epoxide	<8	<10	140	<8	<10	<10	<8	<10	<10	<8	<10	<10	<8	<10	<10
MCPA	<5,000	9,300J	<5,000	<5,000	<21,000	<5,000	<5,000	<8,000	<5,000	<5,000	<12,000	<5,000	<5,000	<8,400	<5,000
Nonachlor, trans-	55	NA	NA	<8	NA	NA	<8	NA	NA	<8	NA	NA	<8	NA	NA
Pentachlorophenol	<50	59.2	55	<50	2.4J	<50	<50	<2.0	16J	<50	53.1	27J	<50	0.71J	32J
2,4-DP (Dichloroprop)	<50	<30	NA	<50	4.4J	<50	<50	<20	<50	<50	<31	NA	<50	4.3J	NA
2,4,5-T	<50	0.70J	<50	<50	<5.2	<50	<50	<2.0	<50	<50	<3.1	<50	<50	<2.1	<50
2,4-DB	<50	<30	<50	<50	<52	<50	<50	<20	<50	<50	<31	<50	<50	8.1J	<50

Concentrations of detected analytes are shown in bold print.
 Concentrations are based on dry weight of sample.
 < Indicates compound was analyzed for but not detected at the numerical method detection limit stated.
 J Indicates the reported value is an estimate.

Notes: Analytes included in this table were present in concentrations above the detection limit in at least one sample.
 B Indicates analyte was found in the associated laboratory blank as well as in the sample.
 ** SS05 (Sed 05) is a duplicate sample collected from sediment sample location SS03 on June 15, 1998 and May 5, 1999. The duplicate sample was collected from sediment sample location SS04 on October 16, 1999.
 NA Not Analyzed.
 Samples were not analyzed for VOCs.
 Laboratory did not analyze June 15, 1998 sediment samples for iron.

TABLE 6. SUMMARY OF CHEMICAL ANALYTICAL RESULTS FOR SOIL SAMPLES

Sample ID	RBC*	SO-01	SO-02	SO-03	SO-04	SO-05**
Sample Date	Region III	5 May 1999	5 May 1999	5 May 1999	5 May 1999	5 May 1999
Metals (µg/kg)						
Barium	5,500,000	42,000	29,000	33,000	130,000	33,000
Chromium	---	20,000	26,000	25,000	79,000	40,000
Cobalt	4,700,000	12,000	12,000	12,000	18,000	14,000
Copper	3,100,000	42,000	40,000	35,000	50,000	51,000
Iron	23,000,000	25,000,000	23,000,000	24,000,000	38,000,000	26,000,000
Mercury	---	< 120	120	< 120	190	< 110
Nickel	1,600,000	15,000	22,000	16,000	30,000	25,000
Silver	390,000	< 2,300	3,300	< 2,300	< 2,800	< 2,400
Zinc	23,000,000	58,000	200,000	370,000	110,000	370,000
Pesticides, PCBs, & Herbicides (µg/kg)						
Dicamba	2,300,000	6.4	< 1.9	2.6	3.1	5.3
MCPA	---	3,100J	3,400J	< 8,100	4,900J	2,400J
2,4-DP (Dichloroprop)	---	6.3J	7.5J	< 21	7.7J	4.6J
Dinoseb	78,000	5.6J	4.0J	6.6J	4.5J	4.1J
Pentachlorophenol	5,300	2.2	3.1	0.81J	1.39J	1.09J

Notes: * RBC - U.S. EPA Region III Risk Based Concentration for soil, residential use.

** Sample ID SO-05 is a duplicate sample of SO-03.

Analytes included in this table were present in concentrations above the detection limit in at least one sample.

Concentrations in bold print and shaded are equal to or above the U.S. EPA Region III RBC

< Indicates compound was analyzed for but not detected at the numerical method detection limit stated.

J Indicates the reported value is an estimate.

Concentrations are based on dry weight of sample.

requirements were not met. The sample locations and corresponding pHs are; MW-01 - pH 3, MW-02 - pH 4, MW-03 (and its duplicate MW-05) - pH 7, and MW-04 - pH 4. Immediately prior to collecting surface water samples, a rain event occurred and surface water samples were collected during a period of high flow. Sediment samples were collected in conjunction with surface water samples. A duplicate sediment sample, identified as SS05, was collected from sediment sample location SS03. Duplicate sample results for all media were consistent with the results of normal samples. Sample matrices and analyses are summarized in Table 1. Laboratory data sheets are provided in Appendix D and the data are summarized on Tables 3-6.

c. October 1999 Sample Analyses.

(1) Based on the analytical results of samples collected in June 1998 and May 1999, selected analyses was performed on a third set of ground-water, surface water and sediment samples. Ground-water samples were collected on 15 October and were analyzed for SVOCs, total metals, pesticides, herbicides, and PCBs. Surface water and sediment samples were

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collected on 14 October 1999. These samples were analyzed for total metals, pesticides, herbicides, and PCBs. All samples analyses were performed by USACHPPM's analytical laboratory.

(2) Sample matrices and analyses are summarized in Table 1. Laboratory data sheets are included as Appendix D and results are summarized on Tables 3-6. A duplicate ground-water sample (MW-05) was collected from monitoring well MW-03. Duplicate surface water and sediment samples (SW05 and SS05) were collected from surface water and sediment sampling points SW04 and SS04. Surface water samples were collected during low flow conditions and were very turbid.

2. Sample Analytical Results

a. Ground-Water Sample Results.

(1) Volatile Organic Compounds. Chloroform and 4-Isopropyltoluene were the only VOCs detected in ground-water samples (see Table 3). Chloroform was detected in the two samples collected from MW-01 and MW-04 at concentrations less than 10 parts per billion (ppb), an order of magnitude lower than the National Primary Drinking Water Regulation maximum contaminant level (MCL) of 100 ppb. Estimated concentrations (less than 2 ppb) of 4-Isopropyltoluene were detected in the first sample collected from MW-03 and in its duplicate (MW-05).

(2) Semivolatile Organic Compounds.

(a) Three SVOCs, bis(2-ethylhexyl)phthalate, hexachlorobutadiene, and pentachlorophenol were detected in ground-water samples. Bis(2-ethylhexyl)phthalate was detected in the June 1998 and May 1999 samples collected from MW-01 and MW-04. Concentrations of approximately 5 micrograms per liter ($\mu\text{g/l}$) were detected in both samples from MW-01 and concentrations of 27 $\mu\text{g/l}$ and 15 ($\mu\text{g/l}$) were reported for MW-4. This compound was also detected at a concentration of 34 $\mu\text{g/l}$ in one sample collected from MW-02. Bis(2-ethylhexyl)phthalate is a common laboratory contaminant. An estimated value of 6 $\mu\text{g/l}$ of hexachlorobutadiene was reported for the May 1999 sample collected from MW-03. There are no MCLs for bis(2-ethylhexyl)phthalate or hexachlorobutadiene.

(b) Pentachlorophenol is included in the analyte list for SVOCs and for herbicides and pesticides analyses. Pentachlorophenol was detected in the June 1998 samples collected from MW-03 at an average concentration of 21 $\mu\text{g/l}$. The primary MCL for drinking water for pentachlorophenol is 1 $\mu\text{g/l}$. The detection limit for pentachlorophenol in the SVOCs analyses was <20 $\mu\text{g/l}$. A lower detection, <0.50 $\mu\text{g/l}$, was achieved in the pesticides, herbicides analysis and the reported concentrations of samples collected from MW-03 were 11.2 and 8.9 $\mu\text{g/l}$.

(3) Metals. As shown on Table 3, metals detected in ground-water samples included arsenic, barium, cadmium, chromium cobalt, copper, lead, nickel, selenium, iron, and zinc. Concentrations of barium, chromium, copper, nickel, selenium, and zinc were below MCLs. There is no MCL for cobalt. Concentrations above the MCL were reported for arsenic, cadmium, and lead. The majority of iron concentrations exceeded the Secondary Drinking Water Regulation MCL.

(a) Barium was detected in each sample collected from the monitoring wells at concentrations one order of magnitude less than the MCL. Chromium was detected in the first sample collected from MW-04, and the first and third duplicate samples (labeled MW-05) collected from MW-03 at concentrations below the MCL. Copper was detected in at least one sample collected from each monitoring well at concentrations less than one-tenth of the MCL. Nickel was detected in three samples collected during the first sampling event at concentrations less than one-half of the MCL. Although selenium was detected at a concentration of 5.1 $\mu\text{g/l}$ in the duplicate sample collected during the first sampling event, it was not detected in any other ground-water sample. Zinc was detected in samples collected from each monitoring well at concentrations of one to two orders of magnitude less than MCL. Cobalt was detected in the first samples collected from MW-03 and MW-04 at concentrations of 4.8 $\mu\text{g/l}$ and 38 $\mu\text{g/l}$, respectively, and in the first and third duplicate samples (MW-05) collected from MW-03 at concentrations of 20 $\mu\text{g/l}$ and 14 $\mu\text{g/l}$. There is no MCL for cobalt.

(b) Arsenic was detected in each of the unfiltered ground-water samples collected in June 1998 at concentrations exceeding the MCL of 50 $\mu\text{g/l}$, including the sample collected from the upgradient-monitoring well (MW-01). The highest concentration of arsenic, 140 $\mu\text{g/l}$, was detected in the sample from MW-04. In samples collected in May 1999 arsenic was detected in each sample at levels less than the MCL. These samples were filtered in the field. Arsenic was not detected in the October 1999 unfiltered samples collected from MW-01, MW-02, and MW-04. In the October 1999 sample collected from MW-03 the arsenic concentration was below the MCL. The arsenic concentrations, above the MCL, in the first set of ground-water samples may be related to the close proximity of sampling to well installation and development, and higher turbidity.

(c) Cadmium was detected in only the first sample collected from MW-03 (MW-05). The reported concentration of cadmium in the duplicate sample is 5.4 $\mu\text{g/l}$, which is slightly above the MCL of 5.0 $\mu\text{g/l}$. However, the concentration of cadmium in sample MW-03 (2.8 $\mu\text{g/l}$) is below the MCL. Cadmium was not detected in any sample collected during the second and third sampling events.

(d) Iron was detected in each of the three samples collected from site monitoring wells. Reported concentrations ranged from 98 $\mu\text{g/l}$ (in a filtered ground-water sample) to 75,000 $\mu\text{g/l}$ in an unfiltered sample. The secondary MCL for iron is 300 $\mu\text{g/l}$. All samples

collected during the first sampling event exceeded the secondary MCL. With the exception of the sample collected from MW03, samples that were filtered in the field during the second sampling event were below the secondary MCL. The concentration of iron in the third sample collected from MW02 was below the secondary MCL; however, iron was above the MCL in samples collected from the other site wells. The highest iron concentrations were reported in the first set of samples that were collected and analyzed. The secondary MCL for iron was exceeded by one to two orders of magnitude in several unfiltered samples.

(e) Lead was detected in at least one sample from each monitoring well. Concentrations ranged from non-detect to 31 µg/l. Concentrations exceeding the MCL (15 µg/l) ranged from 21 µg/l to 31 µg/l and were detected in the first and third samples collected from down-gradient wells MW-03 and MW-04.

(4) TPH. TPH was detected in the upgradient ground-water sample, MW-01, and in one downgradient monitoring well, MW-04, at concentrations of 220 µg/l and 210 µg/l, respectively. TPH was not detected in any sample collected during the second sampling event. Based on the results of the second sampling event, TPH was not analyzed for in the third set of samples.

(5) Pesticides, PCBs, & Herbicides. No pesticides or PCBs were detected in ground water. Five herbicides, 2,4,5-TP (silvex), 2,4,5-T, dinoseb, dicamba, and 2,4-DB were detected in the second ground-water sample set only. Silvex was detected in one well (MW-04) at a concentration of 0.432 µg/l, below the MCL of 50 µg/l. An estimated concentration of 0.017 µg/l was reported for the sample collected from the upgradient-monitoring well (MW-01). Dinoseb was detected in samples collected from MW-03 and MW-04 at estimated concentrations of 0.076 µg/l and 0.152 µg/l. The MCL for dinoseb is 7 µg/l. Dicamba was detected in each sample collected during the second sampling event. Concentrations of dicamba ranged from 0.086 µg/l (in sidegradient well MW-02) to 0.101 µg/l (in the upgradient well). There is no MCL for dicamba. Pentachlorophenol was detected in the MW-03 sample collected during the first sampling event, at concentration of 11.2 µg/l. This concentration is above the MCL of 1 µg/l. The detection of pentachlorophenol in MW-03 is consistent with its detection in SVOCs analyses. In the second set of ground-water samples collected at the site, pentachlorophenol was detected in four samples from three wells (MW-02, MW03, and MW-04) at concentrations of two orders of magnitude less than the MCL. This compound was not detected in any sample collected during the third sampling event.

b. Surface-Water Sample Results. No VOCs, pesticides, PCBs, herbicides or TPH were detected in surface water samples. Two SVOCs and eight metals were detected in surface water samples. Surface water sample chemical data is summarized in Table 4.

(1) SVOCs. The SVOCs detected in surface water samples were bis(2-ethylhexyl)phthalate and di-n-butylphthalate. Bis(2-ethylhexyl)phthalate was detected in the second set of samples collected from sampling points SW02 and SW04 at concentrations of 16 µg/l and 9.8 µg/l, respectively. Bis(2-ethylhexyl)phthalate is a common laboratory contaminant. Di-n-butylphthalate was detected in one sample (SW04 collected in May 1999) and the laboratory blank.

(2) Metals.

(a) Arsenic concentrations (see Table 4) in all surface water samples collected in June 1998 are above the Commonwealth of Puerto Rico's maximum allowable concentration (MAC) of 50 µg/l. Arsenic concentrations ranged from 85 µg/l to 430 µg/l. In the samples collected in May 1999 and October 1999, arsenic concentrations exceeding the MAC were reported for SW02 and SW04. Arsenic was below the MAC in samples collected from SW01 and SW03 in May 1999 and below detection limits in October 1999. The highest concentrations of arsenic were consistently reported for samples SW02 and SW04. These sampling points are located near the toe of the two waste piles. The lowest concentrations of arsenic in each of the three sample sets were consistently reported for sample SW03. The SW03 sample point is the most downstream from the waste piles.

(b) Barium was detected in each of the three samples collected from each sampling point. The MAC (1,000 µg/l) was exceeded in two samples, the third sample collected at SW02 (1,200 µg/l) and the first sample collected from SW04 (1,120 µg/l).

(c) Chromium was only detected in surface water samples collected from sampling points SW02 and SW04. Chromium was detected at a concentration of 19 µg/l in the third sample collected at SW02. First and third samples collected at SW04 had concentrations of 28 µg/l and 16 µg/l. There is no MAC for chromium.

(d). Cobalt was detected in the first sample collected at SW01 at a concentration of 6.7 µg/l. Cobalt was detected in the first and third samples collected at both SW02 and SW04. Concentrations range from 8.9 µg/l to 23 µg/l. Cobalt was not detected in any sample collected at SW03. It is noted that the detection limit for cobalt in the second set of samples was elevated (100 µg/l). There is no MAC for cobalt.

(e) Copper was detected in samples collected from each sampling point. With the exception of one sample, copper concentrations were below the MAC of 40 µg/l, and ranged from 6.4 to 31 µg/l. The first sample collected at SW04 had a concentration equal to the MAC for copper, subsequent copper concentrations detected in samples from SW04 were below the MAC.

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(f) Iron concentrations ranged from 190 $\mu\text{g/l}$ to 480,000 $\mu\text{g/l}$. Iron was detected in each sample collected during the three sampling events. There is no MAC for iron. Generally, the iron concentrations are highest in samples collected near the waste piles and decrease in a downstream direction.

(g) Lead was detected in at least two samples collected at each of the four surface water sampling points. Concentrations ranged from non-detect to 111 $\mu\text{g/l}$. Two concentrations exceed the MAC of 50 $\mu\text{g/l}$. The first sample collected from SW04 had a lead concentration of 58 $\mu\text{g/l}$, the second and third sample concentrations at SW04 were 2.9 $\mu\text{g/l}$ and 14 $\mu\text{g/l}$, respectively. The highest lead concentration, 111 $\mu\text{g/l}$, was reported for the third sample collected from the most downstream sampling point (SW03).

(h) Nickel was detected in at least one sample collected at SW01, SW02, and SW04. Nickel concentrations range from 11 $\mu\text{g/l}$ to 24 $\mu\text{g/l}$. This metal was not detected in samples collected at SW03. There is no MAC for nickel.

(i) Zinc was detected in at least one sample collected from each of the surface water sampling points. Reported concentrations ranged from 26 $\mu\text{g/l}$ to 279 $\mu\text{g/l}$. The MAC for zinc is 50 $\mu\text{g/l}$. As shown on Table 3, the MAC was exceeded in the first and third samples collected at SW01 and SW04, the third sample collected at SW03, and in each sample collected at SW02.

c. Sediment Sample Results. Sediment samples were collected in conjunction with surface water samples. The first and second sets of sediment samples were analyzed for SVOCs, metals, TPH, pesticides, herbicides, and PCBs. Based on the results of the first and second sample sets, the third set of samples was analyzed for metals, pesticides, herbicides, and PCBs. A summary of laboratory results is provided on Table 5 and in the following sections.

(1) SVOCs. With the exception of di-n-butylphthalate, SVOCs were detected in only the first sediment sample collected at sampling point SS01. Fluoranthene was detected at a concentration of 790 micrograms per kilogram ($\mu\text{g/kg}$), and seven other SVOCs were detected at estimated values of 549 $\mu\text{g/kg}$ or less. The eight SVOCs were not detected in the second sediment sample collected at the SS01 sampling point. Di-n-butylphthalate was detected in each of the samples collected during the second sampling event, and in the laboratory blank. This compound is a common laboratory contaminant.

(2) Metals. As shown on Table 5, ten metals were detected in sediment samples: arsenic, barium, cadmium, chromium, cobalt, copper, iron, lead, mercury and zinc. Due to laboratory oversight, the first set of sediment samples were not analyzed for iron.

(a) Arsenic. Arsenic concentrations for all sediment samples ranged from below detection limits to 200,000 µg/kg. The metal was detected in each of the samples collected during the first and third sampling events. Arsenic was not detected in four of the five samples collected during the second sampling event during a period of high flow; however, the largest concentration (200,000 µg/kg) of arsenic in any sample was reported for the sample collected from SS02.

(b) Barium. Barium was detected in every sediment sample. Concentrations ranged from 31,000 µg/kg to 270,000 µg/kg.

(c) Cadmium. Cadmium was not detected in the samples collected at SS03 or in any duplicate sample. This metal was detected in the first of the three samples collected at SS01 and SS04, and in the first and third samples collected at SS02. Detected concentrations ranged for 3,000 µg/kg to 6,500 µg/kg.

(d) Chromium. Chromium was detected in every sample, with the exception of the second sediment sample collected from SS02. Reported concentrations ranged from 12,000 µg/kg to 35,000 µg/kg.

(e) Cobalt. Cobalt was not detected in any of the samples collected at SS03. This metal was detected in the third samples collected at SS02 and SS04 at concentrations of 10,000 µg/kg and 17,000 µg/kg, respectively. The only location where cobalt was detected more than once was SS01.

(f) Copper. Copper was detected in every sediment sample. Concentrations ranged from 15,000 µg/kg to 31,000 µg/kg.

(g) Iron. Iron was detected in each sample that was collected and analyzed at concentrations ranging from 13,000,000 to 79,000,000 µg/kg. Each iron concentration was at least an order of magnitude higher than any other detected analyte.

(h) Lead. Lead was detected in each sediment sample collected during the first sampling event. Concentrations ranged from 7,000 µg/kg (in the duplicate sample collected from SS03) to 22,000 µg/kg in sample SS04. Lead was not detected in the second and third samples collected at SS02 and SS03. Lead was detected in one sample collected during the second sampling event, sample SS04 at a concentration of 33,000 µg/kg.

(i) Mercury. Mercury was detected in the third samples collected from SS01, SS02, and SS04 at concentrations ranging from 70 µg/kg to 110 µg/kg. Mercury was not detected in any sample collected at SS03.

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(j) Zinc. Zinc was detected in each sediment sample collected during the three sampling events. Concentrations ranged from 29,000 µg/kg to 130,000 µg/kg.

(3) Total Petroleum Hydrocarbons. Two sediment samples from each sampling point were collected and analyzed for TPH. TPH was detected in every sample at concentrations ranging from 54,000 µg/kg to 190,000 µg/kg.

(4) Pesticides, PCBs, & Herbicides. No PCBs were detected in any sample. Low concentrations of seven pesticides and herbicides were detected in some sediment samples. Due to using different laboratories, the analyte list for the first set of samples varies slightly from the second and third sample sets. Two analytes, chlordane, gamma, and nonachlor,trans, detected in one sample collected during the first sampling event were not analyzed in the second and third sampling event.

(a) Pesticides. Chlordane, cis and trans, chlordene, gamma-, DDD,p,p', DDE,p,p', DDT,p,p', and heptachlor epoxide were detected in some sediment samples. Chlordane, cis and trans, were detected in the first and third samples collected at SS01, the second sample from SS02, and the third sample from SS03. Concentrations for these analytes range from 17 µg/kg to 17,000 µg/kg. Chlordene, gamma- was detected in SS01 (20 µg/kg) and no other sediment sample. This compound was not on the analyte list in the second and third set of samples. DDD,p,p', DDE,p,p', and DDT,p,p' were only detected in the second sample collected at SS04. The concentrations for these compounds ranged from 19 µg/kg to 32 µg/kg. Heptachlor epoxide was detected in only one sample, the third sample collected at SS01.

(b) Herbicides. MCPA was detected in only the second sample collected at SS01, at an estimated concentration of 9,300 µg/kg. In the second sample at SS02, 2,4 DP was detected at an estimated concentration of 4.4 µg/kg. One estimated concentration (0.70 µg/kg) of 2,4,5-T was reported for one sample, the second sample collected at sampling point SS01. The October 1999 duplicate sample (collected at SS04), was the only sample in which 2,4,-DB was detected. Pentachlorophenol was detected in at least one sample collected at each sampling point. As shown on Table 5, pentachlorophenol concentrations ranged from an estimated 0.71 µg/kg to 59.2 µg/kg.

d. Soil Sample Results. Four soil samples were collected on 5 May 1999 and analyzed for metals, pesticides, PCBs, and herbicides. As illustrated on Figure 4, the samples were collected in a topographically high area outside the perimeter of the former waste area, but along the fence line located at the installation boundary. Table 6 provides a summary of the analytical results of the soil samples and a comparison to the U.S. Environmental Protection Agency (EPA) Region III Risk Based Concentration (RBC) for soil, residential use where applicable. The results of the soil samples are discussed in the following sections.

(1) Metals. Nine metals (barium, chromium, cobalt, copper, iron, mercury, nickel, silver, and zinc) were detected in soil samples. Concentrations of detected metals were compared to applicable RBCs. There are no RBCs for chromium and mercury. With the exception of iron, metal concentrations were at least two orders of magnitude less than the applicable RBCs. Iron concentrations were equal to or slightly above the RBC for iron.

(2) Pesticides, PCBs, & Herbicides. No pesticides or PCBs were detected in soil samples. Five herbicides (dicamba, MCPA, 2,4-DP, dinoseb, and pentachlorophenol) were detected (see Table 5). The concentrations of dicamba, dinoseb, and pentachlorophenol are at least four orders of magnitude less than the RBCs. There are no RBCs for MCPA and 2,4-DP.

VI. SUMMARY. Analytes summarized in this section had at least one detection above a regulatory standard or RBC, where applicable. Although surface water samples are compared to the Commonwealth of Puerto Rico's MAC, surface water in intermittent streams is exempt from the MAC if certain conditions are met.

A. Pentachlorophenol was detected in the first ground-water sample collected from monitoring well MW-03 and its duplicate sample at concentrations 11 and 20 times higher than the MCL. This compound was detected at concentrations below the MCL in the sidegradient well (MW02) and the two downgradient wells in the second set of samples, and was not detected in any sample collected during the third sampling event. Pentachlorophenol was not detected in surface water but was detected in stream sediments. This compound was present in some second and third samples collected from the stream midpoint and near the waste piles. The reported detections ranged from 0.71 ppb to 59.2 ppb. Concentrations of pentachlorophenol reported for each of the four soil samples were below the RBC of 5,300 ppb.

B. Arsenic was detected in the upgradient, sidegradient and downgradient ground-water samples collected during the first sample event at concentrations above the MCL. In many geographic areas arsenic is naturally occurring. The main use of arsenic is the manufacture of pesticides. Elevated concentrations of arsenic in the upgradient and side-gradient monitoring wells indicate that the presence of this metal in ground water is from off-site and is not due to activities associated with the waste disposal area. Elevated metal concentrations are often associated with sample turbidity and the first set of ground-water samples were turbid. The second set of samples was filtered, and arsenic was detected in each sample at concentrations below the MCL. Arsenic was not detected in the third set of samples collected from the upgradient well, sidegradient well, and one downgradient well (MW04). The concentration of arsenic in the second downgradient well (MW03) was below the MCL. Concentrations of arsenic were above the MAC in each surface water sample collected from the base of the waste piles. The concentration of arsenic in the first surface water samples (SW01 and SW03) collected downstream of the waste piles were also above the MAC, but concentrations were

below the MAC in the second samples and non-detect in the third sample set. Arsenic was detected in the majority of stream sediment samples. Non-detects were reported for stream sediment samples collected during a period of high flow. Arsenic was not detected in any soil sample. Ground-water samples, which had arsenic concentrations above the MCL, were turbid. Surface water samples collected from the base of the waste piles were more turbid than downstream samples. Because arsenic was detected above the MCL in the first and most turbid ground-water sample set, and the increased turbidity of upstream samples compared to downstream samples, it is inconclusive if the waste piles or the turbidity of the samples is the reason for the elevated arsenic concentrations in surface water. Arsenic in surface water downstream from the disposal area was below the MAC or non-detect in the samples collected in May and October 1999.

C. Copper was detected in ground-water samples below the MCL. One surface water sample had a reported copper concentration equal to the MAC for surface waters. Copper was detected in each stream sediment sample. This metal was also detected in soil samples at concentrations below the RBC. Based on the analytical data, this metal is naturally occurring and poses no potential threat to human health or the environment.

D. Iron exceeded the secondary MCLs in the majority of ground-water samples, including the first and third samples collected from the upgradient monitoring well. Iron was detected in each surface water, sediment and soil sample. Iron in soil samples collected topographically upgradient and outside the limits of the waste disposal area exceeded the RBC of 23,000,000 $\mu\text{g/kg}$.

E. Lead was detected in at least one ground-water sample collected from all monitoring wells. Lead concentrations were below the MCL (15 $\mu\text{g/kg}$) in samples collected from the upgradient and sidegradient monitoring wells. In the first and third samples collected from the downgradient monitoring wells lead exceeded the MCL by two times or less. Lead was detected in each surface water sample collected during low flow conditions, and in two samples collected during high flow. The MAC for lead (50 $\mu\text{g/kg}$) was exceeded in one of the three samples collected from sample points SW03 and SW04. The highest concentration of lead (111 $\mu\text{g/kg}$) was reported in the most downstream sample (SW03) from the waste piles. Lead was detected in at least one of the three samples collected from stream sediment sampling points and was consistently detected in the samples collected from at the base of one waste pile (SS04). Lead was not detected in soil samples.

F. Zinc was detected in the first and third samples collected from each ground-water monitoring well, and in two samples collected during the second sampling event. Zinc in ground water did not exceed the secondary MCL of 5,000 $\mu\text{g/kg}$. The MAC for zinc in surface water is 50 $\mu\text{g/kg}$, and zinc in the majority of surface water samples exceeded the MAC. This metal was also detected in each stream sediment sample and in soil samples. Zinc

concentrations in soil were below the RBC. Based on the chemical analytical results of soil and ground-water samples, zinc is naturally occurring.

G. TPH was detected in the first of two samples but not in the second samples collected and analyzed for this parameter in upgradient monitoring well MW01 and in one downgradient monitoring well (MW04). TPH was not detected in any surface water sample but was detected in both stream sediment samples collected from four sample locations. Soil samples were not analyzed for TPH. The concentrations of TPH in sediment samples may be associated with the reported disposal of sawdust used to clean up a diesel spill that was containerized in plastic bags in the waste disposal area.

VII. CONCLUSIONS.

A. Ground water exists under water table conditions and flows in a northwesterly direction.

B. Low concentrations of pentachlorophenol were detected in soil, ground-water and sediment samples. Pentachlorophenol was not detected in any surface water sample. In June 1998, pentachlorophenol was detected in only one ground-water sample and the concentration was above the MCL. Pentachlorophenol was detected in three ground-water samples at concentrations below the MCL in May 1999. In October 1999, pentachlorophenol was not detected in any sample. Based on the low concentrations of pentachlorophenol in soil (below EPA, Region III, RBC for soil, residential use), ground water (below the MCL), and sediment, there is no threat to human health or the environment from this compound.

C. In samples collected in June 1998, arsenic was detected at concentrations above the MCL in the upgradient, sidegradient, and downgradient ground-water samples. Arsenic concentrations were below the MCL in field filtered samples collected in May 1999. Arsenic was not detected in three of the four unfiltered ground-water samples collected in October 1999, and was detected at a concentration less than the MCL in the fourth sample. Elevated concentrations of arsenic in the upgradient and side-gradient monitoring wells indicate that the presence of this metal in ground water is from off-site and is not due to activities associated with the waste disposal area. Elevated metal concentrations are often associated with sample turbidity and the first set of ground-water samples was turbid. Arsenic was not detected in soil samples (collected outside the limits of the former waste disposal area). Arsenic was detected in sediment samples collected from each of the four sampling points; the highest concentrations were reported for samples collected near one of the waste piles located within the intermittent stream channel. Arsenic concentrations were consistently above the MAC in each surface water sample collected near the waste piles within the intermittent stream channel. These samples were also more turbid than surface water samples collected downstream. Surface water samples, collected downstream from the waste piles, had arsenic concentrations above

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the MAC in May 1998. Samples collected in May and October 1999 at the same locations had concentrations that ranged from non-detect to less than the MAC.

D. Copper concentrations in ground water ranged from non-detect to less than the MCL. One surface water sample had a reported copper concentration equal to the MAC for surface waters. Copper was detected in each stream sediment, and soil sample and concentrations in soil were below the RBC. Based on the analytical data, copper is naturally occurring and poses no threat to human health or the environment.

E. Iron concentrations in ground water and soil exceed the secondary MCL and the RBC, respectively. High concentrations of iron were also detected in surface water and sediment samples. Based on the analytical data it is concluded that the high iron concentrations are naturally occurring and are not associated with the former waste disposal site.

F. Lead was detected in upgradient, sidegradient, and downgradient ground-water samples collected in May 1998 and October 1999. Concentrations in upgradient and sidegradient samples ranged from non-detect to below the MCL. Lead concentrations in downgradient wells were above the MCL. Lead concentrations in filtered ground-water samples ranged from non-detect to less than the MCL. Elevated (above the MCL) lead concentrations in ground water may be a function of sample turbidity. Lead concentrations in 10 of 12 surface water samples were below the MAC. The MAC was exceeded in one sample collected near a waste pile, and in one sample collected downstream of the former waste disposal area. Based on the presence of lead in upgradient and sidegradient wells, and the fluctuation of lead concentrations above and below the MCL and the MAC over time at some sampling locations, it is concluded that lead is naturally occurring or is migrating from a hydraulically upgradient area, and is not impacting surface water quality near the former waste disposal site.

G. Zinc was detected in ground-water samples at concentrations less than the secondary MCL. Zinc concentrations in surface water exceed the MAC and the MAC is lower than the secondary MCL for ground water. Zinc concentrations decrease in the downstream direction. Zinc concentrations in surface water are consistent with ground-water concentrations. Based on chemical analytical results, zinc is naturally occurring.

H. TPH was detected in the upgradient and in one downgradient ground-water sample collected in June 1998, but was not detected in any sample collected in May 1999. TPH was detected in every sediment sample but was not detected in surface water samples. The presence of TPH in stream sediments is not impacting surface water quality.

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VIII. RECOMMENDATIONS. Based on the low concentrations of the analytes discussed above and in other sections of this report, no further study is recommended for the former waste disposal site.



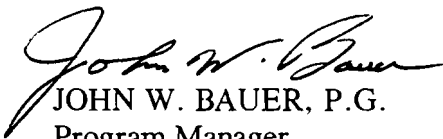
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APPENDIX A

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APPENDIX B

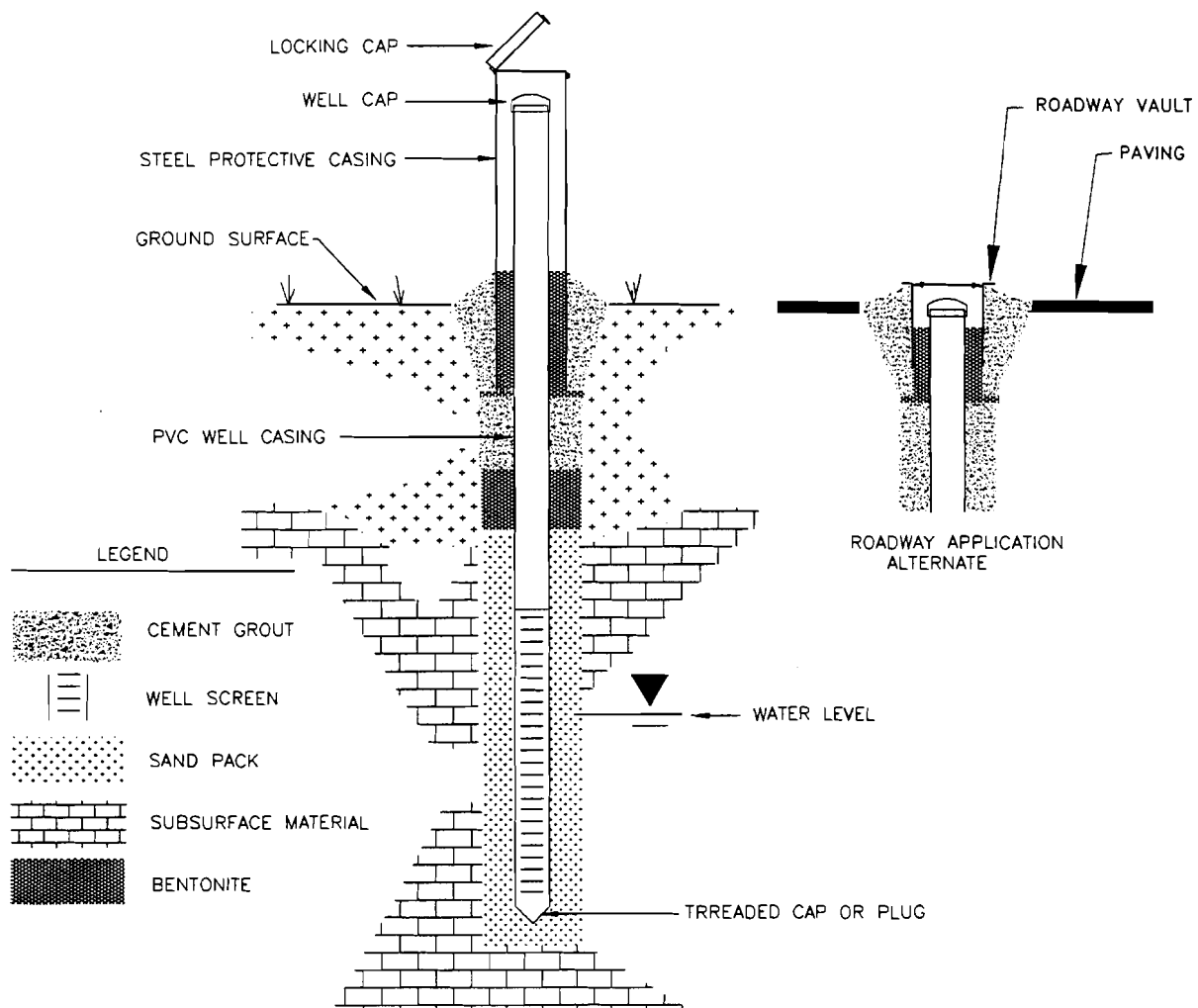
DRILLING, MONITORING WELL CONSTRUCTION, DEVELOPMENT, AND SAMPLE COLLECTION TECHNIQUES

I. DRILLING TECHNIQUES. A truck-mounted Mobile B-53 was used to drill the boreholes at the site. Boreholes were advanced with 4-inch diameter solid stem augers. A USACHPPM geologist logged borings from auger cuttings.

II. CLEANING METHODS. The back of the drill rig, auger flights, and downhole tools were washed with a solution of Alconox® and potable water and rinsed with potable water upon arrival at Fort Buchanan, between boreholes, and prior to leaving Fort Buchanan. Drilling equipment was cleaned at a Fort Buchanan wash rack. Cleaned equipment was placed on plastic sheeting before transporting to drilling locations.

III. MONITORING WELL CONSTRUCTION TECHNIQUES. Monitoring wells were installed in each borehole using open-hole construction techniques. The wells are constructed of 2-inch inside diameter, Schedule 40, flush-threaded polyvinyl chloride (PVC) riser pipe and screen. Screens consist of 10-foot sections of 0.010-inch machine slotted PVC. A 0.5-foot well point was attached to the bottom of each screen. A sand pack of predominately medium silica sand was placed in the annular space around each screen, extending above the well screen. A minimum of 3 feet of bentonite pellets were placed on the sand pack and hydrated with distilled water. The remaining annular space was filled with cement. A steel protective casing with a hinged locking cap was installed over the well pipe at MW1 and MW4. An approximate 1-foot by 1-foot cement pad was poured around the protective casing. Monitoring wells MW2 and MW3 were fitted with locking well caps, and flush-mounted protective casings were installed over these wells. A cement apron, which slopes away from the wells, was poured around the flush-mounted casing. All well caps were vented. Generalized monitoring well construction diagrams are provided on Figure B-1 and a well construction summary is provided in Table B-1.

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CENTER FOR HEALTH PROMOTION
AND PREVENTIVE MEDICINE
ABERDEEN PROVING GROUND, MARYLAND

FIGURE B-1.
GENERAL MONITORING WELL CONSTRUCTION
FORT BUCHANAN, PUERTO RICO.

DRAWN BY:	PROJ #:	FILE:
GCL	38-EH-8181-98	WELLS/GENM-W.DWG

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Geohydrologic Study No. 38-EH-8181-98, 11-16 Jun 98, 4-5 May 99, and 14-16 Oct 99

TABLE B-1. GROUND-WATER MONITORING WELL CONSTRUCTION SUMMARY
FORMER WASTE DISPOSAL AREA, FORT BUCHANAN

WELL NUMBER	MW-01	MW-02	MW-03**	MW-04
1. Height of Monitoring Well Casing Above Ground Level	1.0	-0.2	-0.2	2.0
2. Total Depth of Well Below Ground Level	19.2	42.7	40.2	28.0
3. Depth to Top of Well Screen Below Ground Level	8.7	32.5	29.7	17.5
4. Well Screen Length	10	10	10	10
5. Well Screen Slot Size	0.010"	0.010"	0.010"	0.010"
6. Well Diameter	2"	2"	2"	2"
7. Monitoring Well Casing Material	PVC	PVC	PVC	PVC
8. Monitoring Well Screen Material	PVC	PVC	PVC	PVC
9. Grout Thickness Below Ground Level	4.2	19	1.5	6
10. Depth to Top of Bentonite Seal Below Ground Level	4.2	19	1.5	6
11. Bentonite Seal Thickness	3.3	7.5	9.5	6.4
12. Depth to Top of Sand Pack from Ground Surface	7.5	26.5	11.0	12.4
13. Elevation - Top of Monitoring Well Casing	120.74	107.02	96.77	114.4
14. Elevation at Ground Level	119.74	107.22	96.97	112.4
15. Depth to Static Water Level				
a. Date Measured	6/16/98	6/16/98	6/16/98	6/16/98
b. From Top of Monitoring Well Casing	8.85	26.44	28.49	20.66
c. From Ground Level	7.85	26.64	28.69	18.66
d. Water Level Elevation	111.89	80.58	68.28	93.74

Comments: All measurements are in feet unless otherwise stated.

Flush mount protective casings were installed on MW2 and MW3.

** Pellets were placed in MW3 to 10.5' bgs. Approximately 2.5 cubic feet of grout was placed in the borehole; the grout would not rise, so bentonite pellets were added to 1.5' bgs.

IV. MONITORING WELL DEVELOPMENT. On 15 June 1998, monitoring wells were developed by bailing and surging with stainless steel bailers. The bailers were cleaned prior to use in each well by washing with a solution of Alconox and distilled water and by rinsing with distilled water. Each well was developed until purged to dryness. Well volumes were calculated based on the standing water in the well pipe. Three well volumes were removed from MW1 and MW4, four well volumes from MW3, and approximately 1-1/2 well volumes from MW2. The pH, conductivity, and temperature were recorded during development.

V. WATER LEVEL MEASUREMENTS. Water levels were measured in each monitoring well with a battery-operated water level indicator. The water level indicator probe was lowered into the well and used to measure the depth to water from the top of the well casing. Water level measurements were made to the nearest 0.01-foot. These measurements were subtracted from the elevation at the top of the casing to determine the ground-water elevation inside the well above mean sea level. Water level measurements were used to determine well volumes and ground-water flow direction.

VI. SAMPLING AND ANALYSIS METHODS.

A. Ground-Water Sample Collection.

1. The first-set of ground-water samples were collected after well development. Because the wells had been purged to dryness during development, the wells were not repurged immediately prior to sampling. Purging and sampling data are provided on Table B-2. Samples were collected within 24 hours of purging the wells during development. Samples were collected with pre-cleaned, polyethylene, disposable bailers with new nylon cord. A new pair of latex gloves was worn at each monitoring well during sample collection.

2. In May 1999, low flow pumps were tried to purge wells. Due to a combination of factors including pump size, depth to water, and slow recovery the pumps could not be used to purge and sample the wells. On 3 May 1999, wells were purged with pre-cleaned stainless steel bailers with new nylon cord attached. Samples were collected with pre-cleaned, polyethylene, disposable bailers with new nylon cord within 24 hours of well purging. A new pair of latex gloves was worn at each monitoring well during sample collection. Wells in October 1999 were purged with pre-cleaned stainless bailers with new nylon rope. Samples were collected within 24 hours of purging. Samples were collected with pre-cleaned, polyethylene, disposable bailers with new nylon cord. A new pair of latex gloves was worn at each monitoring well during sample collection.

TABLE B-2. PURGING AND SAMPLING DATA FOR GROUND-WATER MONITORING WELLS AT THE FORMER WASTE DISPOSAL AREA, FORT BUCHANAN

WELL NUMBER	WATER LEVEL		PURGING					
	Date	Depth to Water ¹ (feet)	Total Well Depth ² (feet)	Standing Water (feet)	1 Well Volume ³ (gallons)	Amount Purged (gallons)	Well Bailed Dry	Date
MW-01	6/15/98	8.65	20.2	11.6	2.0	6	YES	6/16/98
MW-02	6/15/98	26.0	42.5	16.5	2.8	4	YES	6/16/98
MW-03	6/15/98	28.10	40.0	11.9	2.0	3	YES	6/16/98
MW-04	6/15/98	16.75	30.0	13.2	2.2	7	YES	6/16/98
MW-01	5/3/99	10.35	20.5	10.1	1.7	5	NO	5/4/99
MW-02	5/3/99	27.87	42.7	14.8	2.5	4	YES	5/4/99
MW-03	5/3/99	29.67	40.0	10.3	1.8	3	YES	5/4/99
MW-04	5/3/99	25.05	30.5	5.4	0.9	1.8	YES	5/4/99
MW-01	10/15/99	9.73	20.2	10.8	1.8	2	YES	10/16/99
MW-02	10/15/99	27.81	42.9	15.1	2.8	3	YES	10/16/99
MW-03	10/15/99	29.05	40.4	11.3	2	5	YES	10/16/99
MW-04	10/15/99	24.40	30.0	5.6	1	3	YES	10/16/99

NOTES:

¹ The depth to water was measured in feet from the top of the PVC well casing with an electric water level indicator.

² The total well depth was measured in feet from the top of the PVC well casing.

³ One well volume = [(total well depth) - (depth to water)] x [conversion factor (0.17)]

B. Surface water Sample Collection. Surface water samples were collected beginning at the most downstream point and then moving up the stream channel. Samples were collected by gently submerging the sample container below the surface of the water. The sample container was kept submerged until full and then immediately capped. New latex gloves were worn at each sample location.

C. Stream Sediment Sample Collection. Sediment grab samples were collected to a depth of 4 to 6 inches using a clean trowel, placed in a clean stainless steel bowl, mixed, and placed in laboratory-supplied containers. All equipment was decontaminated between sample collection sites. Clean, new latex gloves were worn at each sediment sample location.

D. Soil Sample Collection. Soil samples were collected from an approximate depth of 6 inches below ground surface with a precleaned stainless spoon. Soil was placed in a precleaned stainless steel bowl, mixed, and placed in the appropriate laboratory supplied containers.

E. Sample Containers, Handling, And Preservation. Each sample container was labeled with the installation name, project number, project officer, date sampled, sample identification, analysis required, and preservative information during sample collection. Samples were immediately placed in a cooler filled with ice to maintain a temperature of approximately 4° C. Coolers containing sample jars were taken to the Fort Buchanan's Environmental Office where the sample jars were transferred to a refrigerator with a temperature of 4°C. Laboratory-supplied temperature control bottles were kept with the sample jars. Sample jars were subsequently packed in coolers with ice and temperature control bottles, and transported to Federal Express in San Juan, Puerto Rico, for shipment to the USACHPPM laboratory. USACHPPM's laboratory then shipped samples to contract laboratories for selected analyses.

F. Analytical Methods. USACHPPM's laboratory in Aberdeen Proving Ground, Maryland; Lancaster Laboratories, Incorporated, in Lancaster, Pennsylvania; and Gascoyne Laboratory, Inc., in Baltimore, Maryland; analyzed samples. A summary of the analytical methods is provided in following paragraphs. Laboratory data sheets are included as Appendix D.

1. June 1998. Ground-water and surface water samples were analyzed for VOCs using EPA method 8260B. All water and sediment samples were analyzed for SVOCs using EPA method 8270B. Metals in water were analyzed by one of the following EPA methods; 6020, 6010B, or 7470A/7471. One of the following EPA methods; 6010B, 7041, 7060A, 7421, or 7471A were used to analyze metals in sediment samples. The analytical method used for each metal is provided on the laboratory data sheets contained in Appendix D. Method 418.1 was used to analyze samples for TPH. Pesticides and PCBs were analyzed using

USACHPPM/Directorate of Laboratory Sciences (DLS)/Chromatographic Analysis Division (CAD) Standard Operating Procedure (SOP)#38.1, a USACHPPM in-house method. Herbicides in water samples were analyzed using USACHPPM/DLS/CAD SOP #15.1, an in-house method based on EPA Method 8151A. Pesticides and PCBs, and herbicides in sediment samples were analyzed using methods CAD SOP #38.1 and CAD SOP #29.1, respectively. CAD SOP #29.1 is based on EPA Method 8151A.

2. May 1999. Ground-water VOCs samples were analyzed using EPA Method 5030B/8260B. SVOCs in ground-water, surface water, and sediment samples were analyzed by Analytical Spectrometry Division (ASD) Sop #72.4. Metals in water, sediment, and soil samples were analyzed by one of the following EPA methods; 6020, 6010B, or 7470A/7471. All TPH analyses were done under EPA method 418.1. In ground-water samples pesticides and PCBs were analyzed for using EPA Methods 8081A/8082. Pesticides and PCBs in soil and sediment samples were analyzed using USACHPPM/DLS/CAD SOP #:OECD 114.2 which is based on EPA Methods 3550B and 8081A/8082. Herbicides analyses for all samples were performed using EPA Method 8151A.

3. October 1999. The method used to analyze surface water, and ground-water samples for metals was EPA Method 6020. Sediment samples were analyzed for metals by one of the following EPA Methods, 6010B, 7060, 7740, 7470, or 7471A. Pesticides, and PCBs were analyzed for by USACHPPM/DLS/CAD SOP #47.1, this method is based on EPA Methods 3510C and 8081A/8082. Water samples were analyzed for herbicides using USACHPPM/DLS/CAD SOP #15.1, based on EPA Method 8151A. Sediment samples were analyzed for herbicides using USACHPPM/DLS/CAD SOP #40.1, this method is based on EPA Methods 8081A/8082.

G. Quality Assurance/Quality Control. Laboratory-supplied trip blanks accompanied sample containers for VOCs and SVOCs throughout the transportation, storage, sampling, and analytical processes. Matrix spike and matrix spike duplicate samples were collected from one monitoring well and submitted to the laboratory. Blind duplicate samples were also collected and submitted to the laboratory for analysis. Chain-of-Custody records were maintained for all samples.

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Geohydrologic Study No. 38-EH-8181-98, 11-16 Jun 98, 4-5 May 99, and 14-16 Oct 99

APPENDIX C
DRILLING LOGS

U.S. ARMY CENTER FOR HEALTH PROMOTION AND PREVENTIVE MEDICINE
GROUND WATER & SOLID WASTE PROGRAM
DRILLING LOG

1 of 3

BORE HOLE <u>B-2</u>	
INSTALLATION <u>Fort Buchanan</u>	
PROJECT NUMBER <u>38-EH-8181</u>	DATE <u>June 13, 1998/0750-1015</u>
LOCATION <u>See well location map</u>	GEOLOGIST <u>Bridgett Lyons</u>
	DRILLERS <u>William Smithson</u>
	<u>Douglas Bazemore</u>
	DRILL RIG <u>Truck mounted Mobile B-53</u>

NOTES Boring logged from cuttings. depth and descriptions are approximate. Boring drilled with 4" O.D. solid stem augers

DEPTH (feet)	DESCRIPTION	REMARKS
0	(0-0.5') Top soil. (0.5-4') Weathered limestone.	
5	(4-7') Yellow, SILTY CLAY and fine sand, weathered friable, limestone chips.	Location of rock layers based on drill rig reactions.
	(7-7 1/2') Rock layer (weathered limestone). Cuttings: Yellowish-brown, SILTY CLAY and fine sand, soft, moist.	
	(9-9.5') Rock (weathered limestone).	
10	Cuttings: Same as above.	
	(12-12.5') Rock layer (weathered limestone).	
	Cuttings: Same as above.	
15		
	17' - Drilling became tighter.	
	18' - Drilling easier.	
20		

U.S. ARMY CENTER FOR HEALTH PROMOTION AND PREVENTIVE MEDICINE
GROUND WATER & SOLID WASTE PROGRAM
DRILLING LOG

Sheet 2 of 3

BORE HOLE B-2
INSTALLATION Fort Buchanan
PROJECT NUMBER 38-EH-8181
LOCATION See well location map

DATE June 13, 1998/0750-1015
GEOLOGIST Bridgett Lyons
DRILLERS William Smithson
Douglas Bazemore
DRILL RIG Truck mounted Mobile B-53

NOTES Boring logged from cuttings, depths and descriptions are approximate. Boring drilled with 4" O.D. solid stem augers

DEPTH (feet)	DESCRIPTION	REMARKS
20	(21-22') Stiff drilling.	
	Cuttings: Yellow, soft, SILTY CLAY, trace to little fine sand, moist, pliable.	
25	(25-31') Interbedded, weathered limestone and CLAYEY SILT TO SILTY CLAY.	Drilling alternates between soft and hard.
30	(31-32.5') Rock layer (weathered limestone).	
	Cuttings: Yellow, SILTY CLAY, some fine sand, moist.	
35	(37-38') Rock layer (weathered limestone).	
	Cuttings: Same as above.	
40		

U.S. ARMY CENTER FOR HEALTH PROMOTION AND PREVENTIVE MEDICINE
GROUND WATER & SOLID WASTE PROGRAM
DRILLING LOG

Sheet 3 of 3

BORE HOLE <u>B-2</u>	
INSTALLATION <u>Fort Buchanan</u>	
PROJECT NUMBER <u>38-EH-8181</u>	DATE <u>June 13, 1998/0750-1015</u>
LOCATION <u>See well location map</u>	GEOLOGIST <u>Bridgett Lyons</u>
	DRILLERS <u>William Smithson</u>
	<u>Douglas Bazemore</u>
	DRILL RIG <u>Truck mounted Mobile B-53</u>

NOTES Boring logged from cuttings. depths and descriptions are approximate. Boring drilled with 4" O.D. solid stem augers

DEPTH (feet)	DESCRIPTION	REMARKS
40	(44-48') Cuttings: gray, fine SAND, some to and silty clay, soupy, thin rock layer at 46' bgs.	
45	End of boring at 48' bgs.	Installed monitoring well MW-02 in borehole. Elevation of ground surface: 107.2' MSL. Water level elevation (June 15, 1998)! 81.02' MSL.
20		

U.S. ARMY CENTER FOR HEALTH PROMOTION AND PREVENTIVE MEDICINE
GROUND WATER & SOLID WASTE PROGRAM
DRILLING LOG

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Sheet 1 of 3

BORE HOLE B-3

INSTALLATION Fort Buchanan

PROJECT NUMBER 38-EH-8181

LOCATION See well location map

DATE June 11, 1998

GEOLOGIST Bridgett Lyons

DRILLERS William Smithson

Douglas Bazemore

DRILL RIG Truck mounted Mobile B-53

NOTES Boring logged from cuttings. depths and descriptions are approximate. Boring drilled with 4" O.D. solid stem augers

DEPTH (feet)	DESCRIPTION	REMARKS
0	(0-8') Brownish yellow, SILTY CLAY to CLAYEY SILT, trace to little fine sand, moist.	Location of rock layers based on drill rig reaction.
5		
10		
	(12-12.5') Rock layer (weathered limestone).	
15	(14-15') Rock layer (weathered limestone).	Borehole angles at 13.5' bgs.
	(17'-18') Rock layer (weathered limestone).	
	(19-20') Rock layer (weathered limestone).	
20		

U.S. ARMY CENTER FOR HEALTH PROMOTION AND PREVENTIVE MEDICINE
GROUND WATER & SOLID WASTE PROGRAM
DRILLING LOG

Sheet 2 of 3

BORE HOLE <u>B-3</u>	
INSTALLATION <u>Fort Buchanan</u>	
PROJECT NUMBER <u>38-EH-8181</u>	DATE <u>June 11, 1998</u>
LOCATION <u>See well location map</u>	GEOLOGIST <u>Bridgett Lyons</u>
	DRILLERS <u>William Smithson</u>
	<u>Douglas Bazemore</u>
	DRILL RIG <u>Truck mounted Mobile B-53</u>

NOTES Boring logged from cuttings, depths and descriptions are appropriate. Boring drilled with 4" O.D. solid stem augers

DEPTH (feet)	DESCRIPTION	REMARKS
20	Cuttings: Yellowish, gray, SILTY CLAY AND FINE SAND, wet.	
	(23-24') Rock (weathered limestone).	
25	Cuttings: Yellowish, gray, SILTY CLAY and Fine SAND, moist, wet with depth.	
30		
35	(35-36') Subsurface material stiff.	
40		

U.S. ARMY CENTER FOR HEALTH PROMOTION AND PREVENTIVE MEDICINE
GROUND WATER & SOLID WASTE PROGRAM
DRILLING LOG

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Sheet 3 of 3

BORE HOLE B-3

INSTALLATION Fort Buchanan

PROJECT NUMBER 38-EH-8181

LOCATION See well location map

DATE June 11, 1998

GEOLOGIST Bridgett Lyons

DRILLERS William Smithson

Douglas Bazemore

DRILL RIG Truck mounted Mobile B-53

NOTES Boring logged from cuttings, depths and descriptions are appropriate. Boring drilled with 4' O.D. solid stem augers

DEPTH (feet)	DESCRIPTION	REMARKS
40	Cuttings: Same as above, stiff at 42' bgs.	
	End of boring at 42' bgs.	Installed monitoring well MW-03 in borehole.
		Elevation of ground surface: 96.9' MSL
		Water level elevation (June 15, 1998): 68.67' MSL.

U.S. ARMY CENTER FOR HEALTH PROMOTION AND PREVENTIVE MEDICINE
GROUND WATER & SOLID WASTE PROGRAM
DRILLING LOG

Sheet 1 of 2

BORE HOLE <u>B-4</u>	
INSTALLATION <u>Fort Buchanan</u>	
PROJECT NUMBER <u>38-EH-8181</u>	DATE <u>June 13, 1998/1505-1545</u>
LOCATION <u>See well location map</u>	GEOLOGIST <u>Bridgett Lyons</u>
	DRILLERS <u>William Smithson</u>
	<u>Douglas Bazemore</u>
	DRILL RIG <u>Truck mounted, Mobile B-53</u>

NOTES Boring logged from cuttings, depths and descriptions are approximate. Boring drilled with 4" O.D. solid stem auger

DEPTH (feet)	DESCRIPTION	REMARKS
0	(0-3') Fill.	
	(3-5') Yellow, SILTY CLAY AND FINE SAND, limestone fragments, soft, moist.	Location of rock layers based on drill rig reaction.
5		
	(7.5 - 8') Rock layer (limestone).	
10	(10-10.5') Rock layer (weathered limestone).	
	(11-11.5') Rock layer (weathered limestone).	
	Cuttings: Same as above.	
15		
20		

FINAL LETTER REPORT

Site 12, Old Landfill

**Results of Sediment Porewater Sampling for the
Fort Buchanan Site Wide RCRA Facility
Investigation**

**U.S. ARMY GARRISON
FORT BUCHANAN, PUERTO RICO**

December 2011



Prepared for:

U.S. Army Environmental Command
San Antonio, TX

Contract No. W91ZLK-04-D-0015

1 INTRODUCTION

Site 12, the Old Landfill, is being evaluated in the Site Wide RCRA Facility Investigation (RFI) for Fort Buchanan. Soil, sediment, surface water, and groundwater data have been generated for the site as part of the RFI. The U.S. Environmental Protection Agency (EPA) requested that further evaluation of groundwater downgradient of the landfill be conducted. However, installation of groundwater monitoring wells immediately downgradient of the landfill is not feasible due to the heavy vegetation at the Site and the fact that the area is protected habitat for the endangered species *Epicrates inornatus* (the Puerto Rican boa). Therefore, it was agreed that sediment porewater samples would be collected at the base of the landfill. This letter report summarizes the Site's history, describes the site terrain as it has impacted the sampling design for the site, summarizes previous investigations at the site, and presents the results of the recent sediment porewater sampling effort.

The Army presents this letter report to the EPA in an effort to gain concurrence that sufficient data have been generated to characterize the site and that no further data gaps exist for Site 12.

2 SITE HISTORY

Site 12 is located in the southwest portion of Fort Buchanan, adjacent to and just southwest of the elementary school (Figure 1). Disposal activities are thought to have occurred from the 1960s until the early 1990s. The primary area of activity was approximately two acres including the area between the elementary school (which was constructed in the early 1960s) and the perimeter road (Figure 1).

In July 1979, the site was visited by personnel from the Puerto Rico Environmental Quality Board (PREQB). It was found that the landfill did not meet the requirements of the PREQB's sanitary landfill regulations. In order to obtain a permit for the operation of a landfill, Fort Buchanan was directed to complete an Environmental Impact Statement, consolidate the scattered wastes, install a fence, and comply with the Puerto Rico Planning Board's regulations regarding landfills. In November 1979, Fort Buchanan notified the PREQB that it had completed the specified requirements, and was applying for a landfill operation permit for construction and vegetation debris, and a permit for emergency disposal of domestic and commercial waste in the event that municipal landfills were temporarily closed. Despite the permit application, a 1999 Geohydrologic Study of the Site found that the landfill was not formally permitted, but that Fort Buchanan had PREQB's informal approval for its operation (USACHPPM 1999).

During site visits made in association with the current RFI (i.e. between 2007 and 2011), the

debris observed at the site was construction rubble, and was only observed in the ravine at the west side of the site. The location and disposition of the rubble suggests that the disposal method consisted of pushing material over the edge of the ravine. There is some anecdotal evidence from former base employees that dumping of paint cans, oil drums, and other possibly hazardous materials occurred at the site, but that these materials were later removed (Woodward-Clyde 1997). In August 1979, sawdust was used to clean up a diesel spill. The contaminated sawdust was containerized in plastic bags and placed in this area (Woodward-Clyde 1997). In addition, during cleanup activities after Hurricane Hugo in 1989, debris was reportedly placed in the area and covered with soil (USACHPPM 1999).

3 SITE TERRAIN

As shown in Figure 2, the cleared area where disposal activities are thought to have occurred is limited to the portion of the Site that has a sloping terrain; a ravine is present on the west side of the site. The ravine is steep; the elevation drops about 40-feet in the 75 meters west of the school (Figure 2). Not only is the site characterized by steep topography, but there is also very thick vegetation, bedrock outcrops along the walls of the ravine, and the areas to the south, east, and west are currently protected habitat for the Puerto Rican Boa (*Epicrates inornatus*). Groundwater discharge points are present at the southern end of the ravine where groundwater surfaces and forms a creek/wetland area at the bottom of the ravine. The creek runs north/northwest through the ravine and enters a culvert that flows under the school soccer field at the extreme north end.

4 SITE INVESTIGATIONS

4.1 GEOHYDROLOGICAL STUDY

A geohydrological study of the Old Landfill was completed by the Army in 1999 (USACHPPM 1999). This investigation involved the collection of sediment and surface water samples from the creek west and north of the elementary school, and the installation and sampling of four monitoring wells located in the flatter, upland portion of the Site. The topography of the site, described above, restricted the placement of the monitoring wells. Wells MW-03 and MW-04 were located within the waste disposal area and wells MW-01 and MW-02 were located southeast of the disposal area (Figure 1, wells were also sampled during the current RFI). MW-02 is immediately downgradient of Building 1047, which was a paint storage locker. At the time the well was installed (1998), several old air conditioning units were observed on the ground behind the building. The investigation found that groundwater at the site flows northwest toward

the creek at the bottom of the ravine.

The geohydrological study found elevated concentrations of some metals in sediment and groundwater, and these results were the main impetus for the Army to further investigate Site 12 in the Site Wide RFI.

4.2 SITE WIDE RFI

Early work plans in support of the Site Wide RFI proposed the collection of sediment and surface water samples from the ravine, and the collection of groundwater samples from monitoring wells MW-01 through MW-03 (MW-04 could not be located for sampling, Figure 1). After discussions with regulators, who expressed concern about potential risks to school children from exposure to soil in the field south of the elementary school, four soil sampling locations were added in this area.

The Draft Final version of the RFI found that metals were present in soil at concentrations above screening levels but that all metals concentrations were below background comparison values for soil. Arsenic, chromium, and vanadium were found at elevated concentrations in sediment, surface water, and groundwater. The elevated concentrations of metals in these media are expected to be related to the geology of the area, as was found with the soil samples. A few pesticides were detected in surface soil and sediment at concentrations above ecological screening levels. Chloroform was found in two groundwater samples at concentrations above tapwater screening levels but below Maximum Contaminant Levels (MCLs). Chloroform was detected in MW-01 and MW-02, but was not detected in the more downgradient well MW-03. Data tables for Site 12 soil, sediment, surface water, and groundwater are included as Tables 1 through 4.

The Human Health Risk Assessment (HHRA) completed for Site 12 found that there were no concerns for current or potential future receptors exposed to surface soil, surface water, or sediment, at the site. The HHRA didn't evaluate potential risks from exposure to groundwater because the pathways were considered incomplete. Note that in response to EPA comments, groundwater exposure pathways are being re-evaluated and will be assessed in the next version of the HHRA that will be included in the Site Wide RFI Report. The Baseline Ecological Risk Assessment (BERA) found that terrestrial plants and invertebrates were potentially at risk from metals in soil. However, the risk management evaluation concluded that further efforts to characterize or manage potential risks from soil chemicals of potential concern (COPCs) are unwarranted because on-site concentrations were below background concentrations. The BERA also found that benthic organisms are potentially at risk from arsenic in sediment.

4.3 SEDIMENT POREWATER SAMPLING

After review of the Draft Final version of the RFI, the EPA submitted comments expressing concern that groundwater at the Site had been insufficiently characterized, primarily because no groundwater samples were collected from within the ravine or immediately downgradient on the west side of the site. A conference call was held January 20, 2011 to discuss the EPA comments, and representatives from the EPA, PREQB, EPA contractors (TechLaw), Fort Buchanan, Army Environmental Center, and the Army's contractor (EA Engineering, Science, and Technology) were in attendance. It was explained that installation of a monitoring well or a temporary well point (via direct push technology) was not possible in the ravine area, and that the surface water samples collected from the ravine were representative of groundwater. Based on the groundwater elevations measured at MW-03 (67.1 ft above mean sea level [amsl], USACHPPM 1999) and the measured stream elevation from the topographic maps (Figure 2), the aquifer is hydraulically connected to the stream. It was further explained that the most upgradient surface water sample was collected at the most upgradient location possible within the ravine.

It was agreed that sediment porewater samples would be collected at the base of the landfill to characterize groundwater downgradient of the landfill. Table 5 presents the results of the porewater samples compared to groundwater screening levels and Figure 1 shows the sample locations. Metals and one SVOC were detected in the porewater samples.

When compared to groundwater screening levels, total and dissolved concentrations of arsenic, chromium, cobalt, iron, manganese, and thallium were higher than the EPA tapwater regional screening levels. Concentrations of arsenic and the maximum concentration of total thallium were also higher than the MCL. MCLs are not available for cobalt, iron, or manganese. All dissolved concentrations of thallium were below its MCL.

The SVOC bis(2-ethylhexyl)phthalate was detected in two samples, one of which had a concentration that is above both the MCL and the tapwater RSL. A concentration of 7.5 ug/L was reported in the field duplicate collected at location S12-PW-03; bis(2-ethylhexyl)phthalate was not detected in the parent sample from this same location. This SVOC is also a common laboratory contaminant; however, bis(2-ethylhexyl)phthalate was not detected in the laboratory blank samples. This sampling location is the most upgradient location, and the compound was not detected in downgradient porewater samples.

The sediment porewater data suggest that some metals are present in the porewater at elevated concentrations with respect to human health screening levels. One SVOC has also been found to be present in the porewater. The concentrations of metals detected in the porewater samples are generally consistent with the concentrations found in the Site's surface water and groundwater.

Concentrations of arsenic and barium tended to be higher in porewater, but the concentrations of the other metals were consistent with or lower than concentrations found in the other water media. As has been noted in other reports for Fort Buchanan and discussed in meetings with regulators, certain metals are consistently found at elevated concentrations in the soil of Puerto Rico because of the island's geology. Background studies for metals in media other than soil have not been completed for this RFI, but it is to be expected that the mineral content of the island would impact the concentrations of metals found in sediment, surface water, and groundwater.

The porewater data will be included in the next version of the Site Wide RFI document, and will be evaluated in the risk assessments. As noted in Section 4.2, the HHRA didn't evaluate potential risks from exposure to groundwater because the pathways were considered incomplete at the time of the original RFI submittal. In response to EPA comments, groundwater exposure pathways are being re-evaluated and will be assessed in the next version of the HHRA. The sediment porewater data will be grouped with monitoring well data to evaluate the potential for risks to human receptors from exposure to groundwater at Site 12.

5 CONCLUSIONS

As part of the Site Wide RFI, soil and groundwater from the landfill area and sediment porewater, sediment, and surface water from immediately downgradient of the landfill have been sampled. The data generated from these samples indicate that metals are present in all media at concentrations greater than human health and ecological screening levels. In addition, some organic compounds (pesticides and two PAHs) have been detected at concentrations greater than ecological screening levels in soil, sediment, and surface water samples. Chloroform was detected in groundwater at concentrations above the tapwater screening level but below the MCL, although the compound was not detected in the downgradient well MW-03, nor was it detected in downgradient porewater samples. One organic compound, bis(2-ethylhexyl)phthalate was detected in the porewater samples at concentrations above the human health screening level. Bis(2-ethylhexyl)phthalate was not detected in the most downgradient porewater sample, nor was it detected in downgradient surface water samples.

Prior to receipt of the porewater data, the HHRA presented in the draft RFI report identified no risks to potential receptors from media at Site 12; although exposure to groundwater was not evaluated. The BERA found a potential for risks to benthic organisms from arsenic in sediment. Both risk assessments will be revised to include evaluation of the sediment porewater data.

Based on the locations where elevated concentrations of organic compounds were found, the

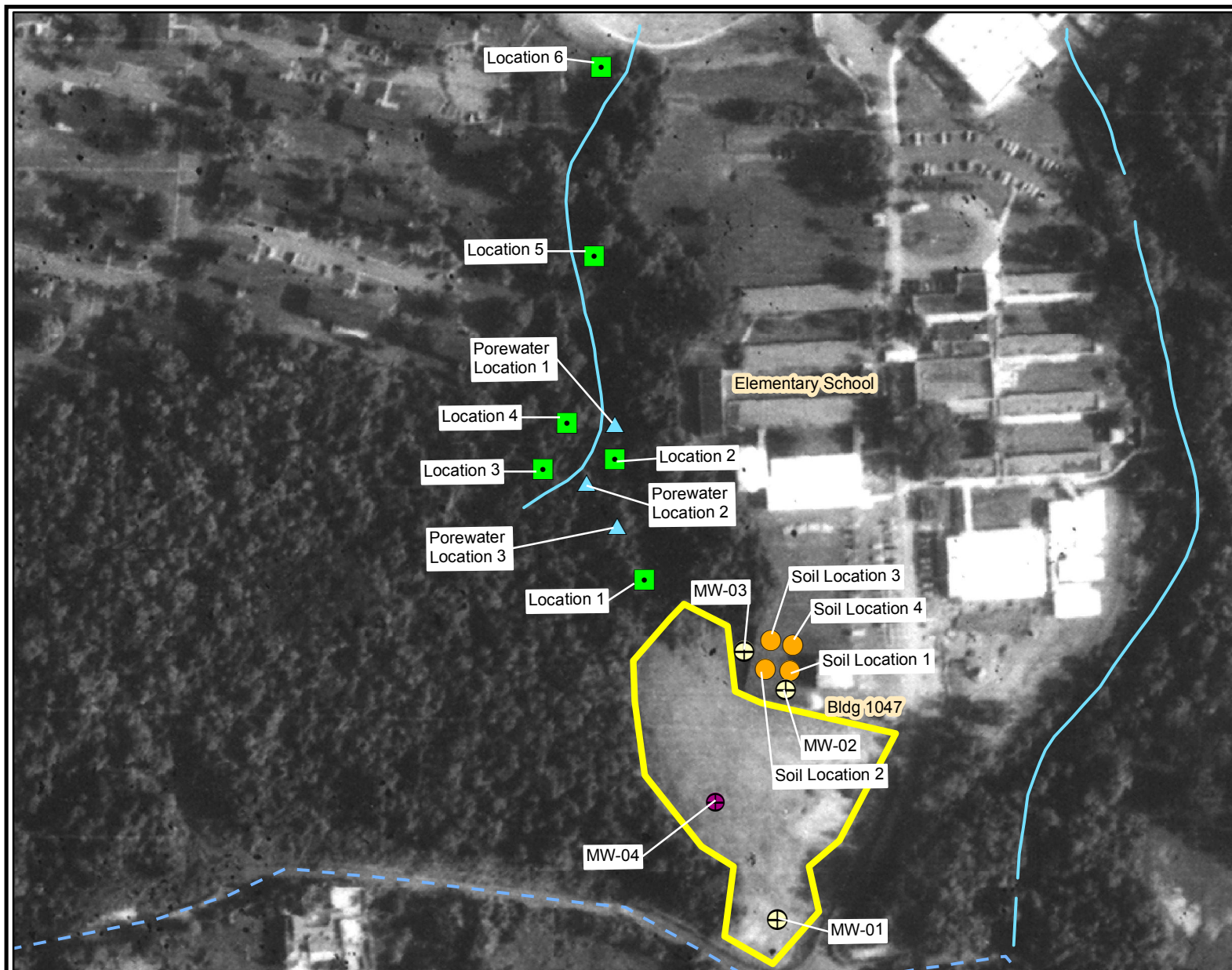
landfill does not appear to be a source area. Elevated metals concentrations were found in all media, but metals occur naturally in the soil of Puerto Rico at concentrations above screening levels. It is to be expected, therefore, that the mineral content of the island would impact the concentrations of metals found in sediment, surface water, and groundwater as well.

6 REFERENCES

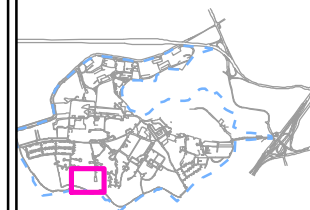
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Area Shown in Main Map



Legend

- ⊕ Historic Well
- RFI Sample Locations
- ⊕ Groundwater
- ▲ Sediment Porewater
- Sed/Surface Water
- Surface Soil
- Landfill Extent Inferred from 1991 Aerial
- Creek
- - - Installation Boundary

Aerial from 1991.

0 25 50
Meters



Fort Buchanan, Puerto Rico

Site 12
Old Landfill

Figure 1
Site 12 in 1991 and
Sample Locations

EA EA Engineering,
Science, and
Technology

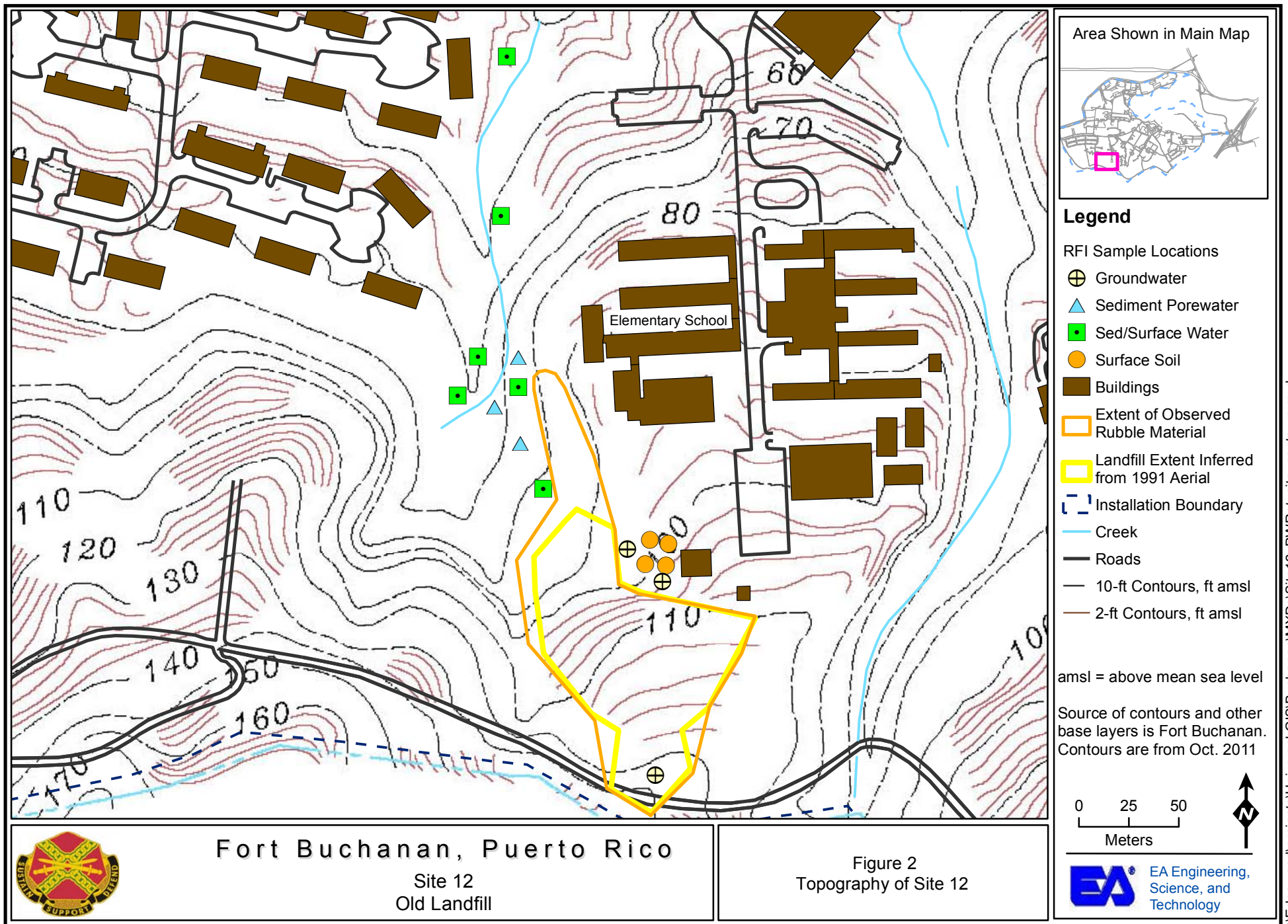


Table 1
Summary of Analytes Detected in Surface Soil at Site 12

Sample Location:					SS-12-01	SS-12-02	SS-12-03	SS-12-03	SS-12-04
Sample Name:					SS-12-07-01-0.5	SS-12-07-02-0.5	SS-12-07-03-0.5	07-AP-24-DP	SS-12-07-04-0.5
Parent Sample Name:								SS-12-07-03-0.5	
Date Sampled:					4/24/2007 & 12/2/2008	4/24/2007 & 12/2/2008	4/24/2007 & 12/2/2008	4/24/2007	4/24/2007 & 12/2/2008
Sample Depth:					0 - 0.5 ft.	0 - 0.5 ft.	0 - 0.5 ft.	0 - 0.5 ft.	0 - 0.5 ft.
Analyte	R4 Eco	EPA I-RSL	EPA R-RSL	Units					
Metals									
Aluminum	50	99000 *	7700 *	mg/kg	<u>19100 J</u>	<u>17000 J</u>	<u>17500 J</u>	<u>16400 J</u>	<u>18400 J</u>
Arsenic	10	1.6	0.39	mg/kg	<u>7.8</u>	<u>7.9</u>	<u>7.9</u>	<u>7.4</u>	<u>6.9</u>
Barium	165	19000 *	1500 *	mg/kg	38.1	51	45.5	46.6	56.5
Beryllium	1.1	200 *	16 *	mg/kg	0.2 J	0.310 J	0.230 J	0.210 J	0.220 J
Cadmium	1.6	80 *	7 *	mg/kg	0.280 J	0.730 U	1.4	1.2	0.76
Calcium	NSA	NSA	NSA	mg/kg	548 J	5320 J	8260 J	7200 J	15500 J
Chromium	0.4	5.6	0.29	mg/kg	<u>27.2</u>	<u>19.6</u>	<u>25.8</u>	<u>22.9</u>	<u>22.8</u>
Cobalt	20	30 *	2.3 *	mg/kg	<u>9.4 J</u>	<u>8.0 J</u>	<u>6.8 J</u>	<u>6.8 J</u>	<u>8.9 J</u>
Copper	40	4100 *	310 *	mg/kg	34	29.2	31	28.6	34.7
Iron	200	72000 *	5500 *	mg/kg	<u>22400 J</u>	<u>20200 J</u>	<u>21100 J</u>	<u>19300 J</u>	<u>23400 J</u>
Lead	50	800 *	400 *	mg/kg	21.1	8.7	46.5	38.8	29.6
Mercury	NSA	10 *	0.78 *	mg/kg	0.097	0.074	0.150	0.150	0.092
Magnesium	NSA	NSA	NSA	mg/kg	3240	2000	1790	1700	2300
Manganese	100	2300 *	180 *	mg/kg	<u>406</u>	<u>404</u>	<u>231</u>	<u>324</u>	<u>403</u>
Nickel	30	2000 *	150 *	mg/kg	10.7	6.6	6.7	6.7	7.1
Potassium	NSA	NSA	NSA	mg/kg	588 J	855	802	762	759
Selenium	0.81	510 *	39 *	mg/kg	2.5 U	2.9 U	2.7 U	2.5 U	2.7 U
Silver	2	510 *	39 *	mg/kg	0.310 J	1.5 U	1.4 U	1.3 U	1.4 U
Sodium	NSA	NSA	NSA	mg/kg	1300 U	1500 U	1400 U	1300 U	1400 U
Thallium	1	1 *	0.078 *	mg/kg	1.3 U	1.5 U	1.4 U	1.3 U	1.4 U
Vanadium	2	520 *	39 *	mg/kg	<u>69.7</u>	<u>60.5</u>	<u>69.7</u>	<u>62.5</u>	<u>77.6</u>
Zinc	50	31000 *	2300 *	mg/kg	<u>78</u>	39.6	43.7	42.2	42.7
Pesticides									
4,4-DDE	2.5	5100	1400	ug/kg	2.2	2.0 U	1.8 U	1.7 U	1.8 U
4,4-DDT	2.5	7000	1700	ug/kg	<u>3.7</u>	2.0 U	1.9	1.7 U	1.8 U
SVOCs									
Benzo[a]anthracene	NSA	2100	150	ug/kg	21.8	9.9 U	9.1 U	8.7 U	8.9 U
Benzo[a]pyrene	100	210	15	ug/kg	14.7	9.9 U	9.1 U	8.7 U	8.9 U
Benzo[b]fluoranthene	NSA	2100	150	ug/kg	19.8	9.9 U	9.1 U	8.7 U	8.9 U
Benzo[k]fluoranthene	NSA	21000	1500	ug/kg	16.2	9.9 U	9.1 U	8.7 U	8.9 U

Table 1
Summary of Analytes Detected in Surface Soil at Site 12

Sample Location:					SS-12-01	SS-12-02	SS-12-03	SS-12-03	SS-12-04
Sample Name:					SS-12-07-01-0.5	SS-12-07-02-0.5	SS-12-07-03-0.5	07-AP-24-DP	SS-12-07-04-0.5
Parent Sample Name:								SS-12-07-03-0.5	
Date Sampled:					4/24/2007 & 12/2/2008	4/24/2007 & 12/2/2008	4/24/2007 & 12/2/2008	4/24/2007	4/24/2007 & 12/2/2008
Sample Depth:					0 - 0.5 ft.	0 - 0.5 ft.	0 - 0.5 ft.	0 - 0.5 ft.	0 - 0.5 ft.
Analyte	R4 Eco	EPA I-RSL	EPA R-RSL	Units					
Bis(2-ethylhexyl) phthalate	NSA	120000	35000	ug/kg	88.0 U	99.0 U	91.0 U	56.3 J	89.0 U
Chrysene	NSA	210000	15000	ug/kg	18.9	9.9 U	9.1 U	8.7 U	8.9 U
Fluoranthene	100	2200000 *	230000 *	ug/kg	33.9 J	99.0 U	91.0 U	87.0 U	89.0 U
Phenanthrene	100	17000000 *	1700000 *	ug/kg	28.5	9.9 U	9.1 U	8.7 U	8.9 U
Pyrene	100	1700000 *	170000 *	ug/kg	28.2 J	99.0 U	91.0 U	87.0 U	89.0 U
Total Petroleum Hydrocarbons									
TPH-DRO (C10-C28)	NSA	100**	100**	mg/kg	18.8	47.9	13.7	---	10.7

April 2007 samples were analyzed for SVOCs, metals, pesticides, herbicides, and PAHs.

December 2008 samples were analyzed for total petroleum hydrocarbons diesel and gasoline range organics and PCBs. PCBs were not detected. Compounds not listed on the table were not analyzed for and/or not detected in any samples.

EPA I-HH = EPA Regional Screening Levels for industrial soil, June 2011.

EPA R-HH = EPA Regional Screening Levels for residential soil, June 2011.

R 4 Eco = Region 4 Ecological Screening Criteria for Soil

* = Noncarcinogen; the value has been divided by 10 to achieve a hazard index of 0.1.

**TPH criteria taken from adopted PREQB standard, unofficial.

NSA = No Screening Criteria Available

--- = not analyzed

J = Estimated

U = not detected, value presented is the reporting limit

Gray shading = detected concentration is > the EPA I-RSL value

Bold font = detected concentration is > the EPA R-RSL value

Underline = detected concentration > the Region 4 Eco value

Table 2
Summary of Analytes Detected in Sediment at Site 12

Sample Location:					SD-12-01	SD-12-02	SD-12-03	SD-12-04	SD-12-04	SD-12-05	SD-12-06	SD-12-06
Sample Name:					SD-12-07-01	SD-12-07-02	SD-12-07-03	SD-12-07-04	07-JN-12-DP4	SD-12-07-05	SD-12-07-06	09-FE-04-DP2
Parent Sample Name:									SD-12-07-04			SD12-09-6
Date Sampled:					6/12/2007 & 2/4/2009	6/12/2007 & 2/4/2009	6/12/2007 & 2/4/2009	6/12/2007 & 2/4/2009	6/12/2007	6/12/2007 & 2/4/2009	6/12/2007 & 2/4/2009	2/4/2009
Analyte	R4 Eco	Adj EPA I-RSL	Adj EPA R-RSL	Units								
Metals												
Arsenic	7.24	16	3.9	mg/kg	<u>21.7</u>	<u>23</u>	<u>35.8</u>	<u>22</u>	<u>17.2</u>	<u>26.2</u>	<u>16.4</u>	---
Barium	NSA	190000 *	15000 *	mg/kg	100	119	231	110	130	88.3	107	---
Beryllium	NSA	2000 *	160 *	mg/kg	0.280 J	0.2 J	0.410 J	0.190 J	0.290 J	0.170 J	0.2 J	---
Cadmium	1	800 *	70 *	mg/kg	0.450 J	0.330 J	0.72	0.410 J	0.440 J	0.280 J	0.360 J	---
Chromium	52.3	56	2.9	mg/kg	<u>24.5</u>	<u>16</u>	<u>23.1</u>	<u>15.2</u>	<u>20</u>	<u>18.4</u>	<u>18</u>	---
Cobalt	NSA	300 *	23 *	mg/kg	8.6	8.0 J	15.2	7.3 J	8.8	6.6 J	6.6 J	---
Copper	18.7	41000 *	3100 *	mg/kg	<u>28.9</u>	15.6	<u>23.6</u>	12.7	<u>20</u>	11.6	15.8	---
Lead	30.2	8000 *	4000 *	mg/kg	22.1	9	9.6	9	8.1	6.8	5.8	---
Mercury	0.13	100 *	7.8 *	mg/kg	<u>0.14</u>	0.084	0.085	0.056	0.13	0.031 J	0.061	---
Nickel	15.9	20000 *	1500 *	mg/kg	8.2	4.8 J	8	4.6 J	5.8	3.4 J	4.0 J	---
Selenium	NSA	5100 *	390 *	mg/kg	2.7	2.6 J	3.5	2.0 J	2.6	2.3 J	1.9 J	---
Silver	2	5100 *	390 *	mg/kg	1.2 U	2.0 U	0.690 J	1.6 U	0.270 J	1.5 U	1.6 U	---
Tin	NSA	610000 *	47000 *	mg/kg	2.4 J	3.5 J	1.2 J	2.8 J	1.4 J	2.4 J	2.9 J	---
Vanadium	NSA	5200 *	390 *	mg/kg	53	34.7	56.2	28.9	41.1	32.7	29.9	---
Zinc	124	310000 *	23000 *	mg/kg	80.5	41	51.6	40.8	45	38.8	34.8	---
Pesticides												
4,4-DDD	3.3	72000	20000	ug/kg	9.4 U	7.6 U	8.0 U	<u>274</u>	7.6 U	5.6 U	6.0 U	---
4,4-DDE	3.3	51000	14000	ug/kg	9.4 U	7.6 U	8.0 U	<u>34.1</u>	7.6 U	5.6 U	6.0 U	---
4,4-DDT	3.3	70000	17000	ug/kg	9.4 U	7.6 U	8.0 U	<u>12</u>	7.6 U	6.8	6.0 U	---
alpha-Chlordane	NSA	65000	16000	ug/kg	9.4 U	7.6 U	8.0 U	---	7.6 U	55.2	6.0 U	---
Dieldrin	3.3	1100	300	ug/kg	9.4 U	7.6 U	8.0 U	<u>11.6</u>	7.6 U	5.6 U	6.0 U	---
Gamma-chlordane	NSA	65000	16000	ug/kg	9.4 U	7.6 U	8.0 U	---	7.6 U	67.9	6.0 U	---
SVOCs												
Anthracene	330	170000000 *	17000000 *	ug/kg	160 U	130 U	140 U	110 U	4.0 U	3.0 U	84.8 J	---
Benzo[a]anthracene	330	21000	1500	ug/kg	16.0 U	13.0 UJ	14.0 U	11.0 U	13.0 U	9.8 U	225	---
Benzo[a]pyrene	330	2100	150	ug/kg	16.0 U	13.0 UJ	14.0 U	11.0 U	13.0 U	9.8 U	122	---
Benzo[b]fluoranthene	NSA	21000	1500	ug/kg	16.0 U	13.0 UJ	14.0 U	11.0 U	13.0 U	9.8 U	174	---
Benzo[g,h,i]perylene	NSA	17000000 *	1700000 *	ug/kg	16.0 U	13.0 UJ	14.0 U	11.0 U	13.0 U	9.8 U	62.8	---
Benzo[k]fluoranthene	NSA	210000	15000	ug/kg	16.0 U	13.0 UJ	14.0 U	11.0 U	13.0 U	9.8 U	52.6	---
Chrysene	330	2100000	150000	ug/kg	16.0 U	13.0 UJ	14.0 U	11.0 U	13.0 U	9.8 U	150	---
Dibenz[a,h]anthracene	330	2100	150	ug/kg	16.0 U	13.0 UJ	14.0 U	11.0 U	13.0 U	9.8 U	25.6	---

Table 2
Summary of Analytes Detected in Sediment at Site 12

Sample Location:					SD-12-01	SD-12-02	SD-12-03	SD-12-04	SD-12-04	SD-12-05	SD-12-06	SD-12-06
Sample Name:					SD-12-07-01	SD-12-07-02	SD-12-07-03	SD-12-07-04	07-JN-12-DP4	SD-12-07-05	SD-12-07-06	09-FE-04-DP2
Parent Sample Name:									SD-12-07-04			SD12-09-6
Date Sampled:					6/12/2007 & 2/4/2009	6/12/2007 & 2/4/2009	6/12/2007 & 2/4/2009	6/12/2007 & 2/4/2009	6/12/2007	6/12/2007 & 2/4/2009	6/12/2007 & 2/4/2009	2/4/2009
Analyte	R4 Eco	Adj EPA I-RSL	Adj EPA R-RSL	Units								
Fluoranthene	330	22000000 *	2300000 *	ug/kg	160 U	130 U	140 U	25.3 J	4.0 U	3.0 U	<u>414</u>	---
Indeno[1,2,3-c,d]pyrene	NSA	21000	1500	ug/kg	16.0 U	13.0 UJ	14.0 U	11.0 U	13.0 U	9.8 U	63.8	---
Phenanthrene	330	170000000 *	17000000 *	ug/kg	16.0 U	13.0 U	14.0 U	26.6	13.0 U	9.8 U	251	---
Pyrene	330	17000000 *	1700000 *	ug/kg	160 U	130 U	140 U	23.5 J	4.0 U	3.0 U	<u>344</u>	---
Total Petroleum Hydrocarbons												
TPH-DRO (C10-C28)	NSA	NSA	NSA	mg/kg	12 U	13 U	14 U	14 U	---	19 U	78.2	63.2

2007 samples were analyzed for VOCs, SVOCs, metals, pesticides, and herbicides.

2009 samples were analyzed for TPH and PCBs. PCBs were not detected.

Analytes not listed on the table were not detected in any samples.

Region 4 Eco = Region 4 Ecological Screening Criteria for Sediment

Adj EPA R-HH = EPA Regional Screening Level for residential soil, June 2011. Value is multiplied by 10 to reflect reduced exposure to sediment compared to soil.

Adj EPA I-HH = EPA Regional Screening Level for industrial soil, June 2011. Value is multiplied by 10 to reflect reduced exposure to sediment compared to soil.

* A noncarcinogen; the value has been divided by 10 to achieve a hazard index of 0.1

NSA = No Screening Criteria Available

--- = not analyzed

J = Estimated

U = Not Detected, reported value is the reporting limit

Gray shading = detected concentration is > the adjusted EPA industrial soil value

Bold font = detected concentration is > the adjusted EPA residential soil value

Underline = detected concentration > the R4 Eco value

Table 3
Summary of Analytes Detected in Surface Water at Site 12

Sample Location:					SW-12-01	SW-12-02	SW-12-03	SW-12-04	SW-12-04	SW-12-05	SW-12-06
Sample Name:					SW-12-07-01	SW-12-07-02	SW-12-07-03	SW-12-07-04	07-JN-12-DP3	SW-12-07-05	SW-12-07-06
Parent Sample Name:									SW-12-07-04		
Sample Date:					6/12/2007 & 2/4/2009	6/12/2007 & 2/4/2009	6/12/2007 & 2/4/2009	6/12/2007 & 2/4/2009	6/12/2007	6/12/2007 & 2/4/2009	6/12/2007 & 2/4/2009
Analyte	R4 Eco	MCL	Adj EPA Tap	Units							
Metals											
Arsenic, dissolved	190	10	0.45	ug/l	8.0 U	5.0 J	5.0 J	5.9 J	8.0 U	8.0 U	8.0 U
Arsenic, total	190	10	0.45	ug/l	89	15.8	10.4	8.0 U	8.0 U	8.0 U	8.0 U
Barium, dissolved	NSA	2000	7300 *	ug/l	75.2 J	113 J	107 J	104 J	101 J	105 J	99.1 J
Barium, total	NSA	2000	7300 *	ug/l	589	281	173 J	131 J	121 J	126 J	110 J
Beryllium, total	0.53	4	73 *	ug/l	1.0 U	0.480 J	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
Chromium, dissolved	11	100	0.43	ug/l	3.4 J	10.0 U	10.0 U	10.0 U	10.0 U	10.0 U	10.0 U
Chromium, total	11	100	0.43	ug/l	3.1 J	8.3 J	1.8 J	10.0 U	1.5 J	10.0 U	1.4 J
Cobalt, total	NSA	NSA	11 *	ug/l	9.5 J	9.5 J	2.7 J	50.0 U	2.2 J	50.0 U	50.0 U
Copper, dissolved	6.54	1300	1500 *	ug/l	3.8 J	3.1 J	25.0 U	25.0 U	25.0 U	25.0 U	25.0 U
Copper, total	6.54	1300	1500 *	ug/l	20.7 J	46.4	42.6	25.0 U	3.6 J	3.7 J	25.0 U
Lead, dissolved	1.32	15	NSA	ug/l	3.0 U	3	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U
Lead, total	1.32	15	NSA	ug/l	6	6.9	3.4	3.0 U	3.0 U	3.0 U	3.0 U
Mercury, dissolved	0.012	2	37 *	ug/l	0.068 J	0.037 J	0.055 J	0.054 J	0.041 J	0.048 J	0.041 J
Mercury, total	0.012	2	37 *	ug/l	0.038 J	0.120 J	0.068 J	0.069 J	0.061 J	0.039 J	0.041 J
Nickel, total	87.71	NSA	730 *	ug/l	3.0 J	5.3 J	3.4 J	40.0 U	40.0 U	40.0 U	40.0 U
Selenium, total	5	50	180 *	ug/l	10.0 U	10.0 U	6.3 J	10.0 U	7.9 J	10.0 U	10.0 U
Silver, dissolved	0.12	NSA	180 *	ug/l	1.4 J	10.0 U	10.0 U	10.0 U	10.0 U	10.0 U	10.0 U
Vanadium, dissolved	NSA	NSA	180 *	ug/l	1.9 J	2.1 J	50.0 U	50.0 U	50.0 U	50.0 U	50.0 U
Vanadium, total	NSA	NSA	180 *	ug/l	7.8 J	23.2 J	6.1 J	50.0 U	5.0 J	3.7 J	3.2 J
Zinc, dissolved	58.91	NSA	11000 *	ug/l	5.0 J	20.0 U	3.6 J	3.5 J	8.7 J	4.4 J	4.3 J
Zinc, total	58.91	NSA	11000 *	ug/l	33	40.6	14.1 J	20.0 U	10.5 J	6.3 J	5.5 J
Pesticides											
4,4-DDE	10.5	NSA	2	ug/l	0.027	0.022 U	0.021 U	0.020 U	0.022 U	0.020 U	0.022 U
SVOCs											
Bis(2-ethylhexyl) phthalate	0.3	6	48	ug/l	1.7 J	2.0 U	2.1 U	2.1 U	2.1 U	2.0 U	2.1 U

Table 3
Summary of Analytes Detected in Surface Water at Site 12

Notes:

2007 samples were analyzed for VOCs, SVOCs, metals, pesticides, and herbicides.

2009 samples were analyzed for TPH and PCBs, neither of which were detected.

Compounds not shown were not detected in any samples.

R4 Eco = EPA Region 4 ecological screening values for freshwater, 2001.

MCL = EPA Maximum Contaminant Level, June 2011.

Adj EPA Tap = EPA Regional Screening Level for Tapwater, June 2011. Value is multiplied by 10 to reflect reduced exposure to surface water compared to groundwater.

* Noncarcinogen; the value has been divided by 10 to achieve a Hazard Index of 0.1

NSA = No Screening Criteria Available

J = Estimated

U = Not Detected, reported value is the reporting limit

Gray shading = detected concentration is > the adjusted EPA Tap value

Bold font = detected concentration is > the MCL

Underline = detected concentration > the R4 Eco value

Table 4
Summary of Analytes Detected in Groundwater at Site 12

Sample Location:				G-12-MW-01	G-12-MW-02	G-12-MW-03
Sample Name:				G-12-07-MW-01	G-12-07-MW-02	G-12-07-MW-03
Date Sampled:				6/13/2007	6/13/2007	6/13/2007
Analyte	MCL	EPA Tap	Units			
Metals						
Arsenic, dissolved	10	0.045	ug/l	8.0 U	8.0 U	10.3
Arsenic, total	10	0.045	ug/l	8.0 U	68.9	8.9
Barium, dissolved	2000	730 *	ug/l	105 J	112 J	194 J
Barium, total	2000	730 *	ug/l	113 J	204	177 J
Beryllium, total	4	7.3 *	ug/l	1.0 U	1.2	1.0 U
Cadmium, total	5	1.8 *	ug/l	4.0 U	2.6 J	4.0 U
Chromium, dissolved	100	0.043	ug/l	10.0 U	10.0 U	1.1 J
Chromium, total	100	0.043	ug/l	73	206	74.5
Cobalt, total	NSA	1.1 *	ug/l	4.5 J	20.1 J	2.6 J
Copper, total	1300	150 *	ug/l	18.7 J	83.9	27.3
Lead, total	15	NSA	ug/l	3.2	14.9	3.0 U
Mercury, dissolved	2	3.7 *	ug/l	0.040 J	0.046 J	0.2 U
Mercury, total	2	3.7 *	ug/l	0.071 J	0.063 J	0.2 U
Nickel, dissolved	NSA	73 *	ug/l	4.6 J	8.1 J	7.2 J
Nickel, total	NSA	73 *	ug/l	35.6 J	90.7	36.1 J
Silver, total	NSA	18 *	ug/l	10.0 U	1.6 J	10.0 U
Vanadium, dissolved	NSA	18 *	ug/l	4.8 J	3.1 J	50.0 U
Vanadium, total	NSA	18 *	ug/l	13.9 J	124	6.4 J
Zinc, dissolved	NSA	1100 *	ug/l	6.5 J	13.1 J	8.8 J
Zinc, total	NSA	1100 *	ug/l	18.1 J	651	16.5 J
VOCs						
Carbon disulfide	NSA	100 *	ug/l	2.0 U	0.460 J	2.0 U
Chloroform	80	0.19	ug/l	5.3	0.460 J	1.0 U

Samples were analyzed for SVOCs, VOCs, TCL Pesticides/PCBs, Herbicides, and TAL Metals.

Analytes not listed on the table were not detected in any samples.

MCL = EPA Maximum Contaminant Level, June 2011.

EPA Tap = EPA Regional Screening Level, June 2011.

* Noncarcinogen; the value has been divided by 10 to achieve a hazard index of 0.1

NSA = No Screening Criteria Available

Gray shading = detected concentration is > the EPA Tap value

Bold font = detected concentration is > the MCL

J = value is estimated

U = not detected, value presented is the reporting limit

Table 5
Summary of Analytes Detected in Sediment Porewater Samples Compared to Groundwater Screening Levels

Sample Location:				S12-PW-01	S12-PW-02	S12-PW-03	S12-PW-03
Sample Name:				S12-PW-11-1	S12-PW-11-2	S12-PW-11-3	S12-PW-11-DP
Parent Sample Name:							S12-PW-11-3
Date Sampled:				9/20/2011	9/20/2011	9/20/2011	9/20/2011
Analyte Name	MCL	EPA Tap	Units				
Metals							
Aluminum, dissolved	NSA	3700 *	ug/l	9.6	200 U	200 U	200 U
Aluminum, total	NSA	3700 *	ug/l	1270	1400	532	403
Arsenic, dissolved	10	0.045	ug/l	36.7	28.6	17.7	18.2
Arsenic, total	10	0.045	ug/l	36.1	34.7	21.9	20.6
Barium, dissolved	2000	730 *	ug/l	197	332	644	673
Barium, total	2000	730 *	ug/l	194	354	672	652
Cadmium, dissolved	5	1.8 *	ug/l	0.4	0.3	0.5	0.6
Cadmium, total	5	1.8 *	ug/l	0.4	0.4	0.4	0.5
Calcium, dissolved	NSA	NSA	ug/l	153000	123000	127000	133000
Calcium, total	NSA	NSA	ug/l	144000	130000	132000	127000
Chromium, dissolved	100	0.043	ug/l	1	1.1	0.9	1.1
Chromium, total	100	0.043	ug/l	4.6	4.5	1.9	1.8
Cobalt, dissolved	NSA	1.1 *	ug/l	1.2	50 U	7.6	7.9
Cobalt, total	NSA	1.1 *	ug/l	1.9	1.9	8.6	8.3
Copper, total	1300	150 *	ug/l	3.3	2.1	10 U	10 U
Iron, dissolved	NSA	2600 *	ug/l	9950	16100	4970	5200
Iron, total	NSA	2600 *	ug/l	11700	20500	6760	6180
Lead, total	15	NSA	ug/l	3 U	5.5	3 U	3 U
Magnesium, dissolved	NSA	NSA	ug/l	12100	12100	12200	12800
Magnesium, total	NSA	NSA	ug/l	11500	12700	12700	12300
Manganese, dissolved	NSA	88 *	ug/l	2060	1740	4450	4630
Manganese, total	NSA	88 *	ug/l	2170	2080	4650	4450
Nickel, dissolved	NSA	73 *	ug/l	4.1	3.3	4.3	4.2
Nickel, total	NSA	73 *	ug/l	5.8	4.2	4.6	4.2
Potassium, dissolved	NSA	NSA	ug/l	1010	2260	5370	5590
Potassium, total	NSA	NSA	ug/l	1110	2390	5610	5380
Sodium, dissolved	NSA	NSA	ug/l	42800	33600	33500	34700
Sodium, total	NSA	NSA	ug/l	41900	35200	34500	33400
Thallium, dissolved	2	0.037 *	ug/l	2 U	1	10 U	1.9
Thallium, total	2	0.037 *	ug/l	1.4	10 U	1.5	2.7
Vanadium, total	NSA	18 *	ug/l	5.5	6.8	1.7	1.2
Zinc, total	NSA	1100 *	ug/l	5.9	7.8	1.9	2.9
SVOCs							
Bis(2-ethylhexyl) phthalate	6	4.8	ug/l	2.3 U	1.3 J	2 U	7.5

Samples were analyzed for metals, VOCs, SVOCs, organochlorine pesticides, organophosphorus pesticides, PCBs, and herbicides.

Compounds not shown were not detected in any samples.

MCL = EPA Maximum Contaminant Level, June 2011.

EPA Tap = Tapwater Regional Screening Level, June 2011.

* = Noncarcinogen; the value has been divided by 10 to achieve a hazard index of 0.1.

Gray shading = detected concentration is > the EPA Tap value

Bold font = detected concentration is > the MCL

J = value is estimated

U = not detected, value presented is the reporting limit